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AGRICULTURAL EXPERIMENT STATION
EAST LANSING

THE QUARTERLY BULLETIN

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
R. E. MARSHALL, ASSISTANT DIRECTOR
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VENTILATED PICKING LUGS

FOR STRAWBERRIES TO BE PROCESSED[1]

By *H. P. GASTON*[2] and *J. H. LEVIN*[3]

MICHIGAN GROWERS produce almost 1,000,000 24-quart crates of strawberries each year. On the average, they received more than $6,500,000 for this crop. In the areas where production is concentrated, growing strawberries is big business.

The crop is of commercial importance in a number of other states. The development of equipment or methods that make it possible to handle strawberries more effectively benefits growers in all parts of the country.

The strawberry is one of our most tender fruits. It must be handled with great care if high quality is to be maintained until it reaches the processor or consumer. The handling methods commonly used often cause considerable mechanical injury.

Strawberry pickers often receive as much as half the total gross returns. Other labor costs are high; and growing, harvesting and handling equipment is expensive. Under these circumstances, profits depend on the grower's ability to produce fruit of high quality and to avoid excessive costs.

The purpose of this study was to find out whether a new type of strawberry lug would reduce costs and, at the same time, make it easier to maintain field quality of strawberries that are to be processed.

[1]Acknowledgments: The authors wish to express their appreciation to David Scott of Northport, and to David Spinniken of Lake Leelanau, the growers in whose strawberry patches the field studies were made. Credit is also due Cherry Growers, Inc., who processed the berries included in the experimental lots and who cooperated in other ways. Stanley Ball, county agricultural agent in Leelanau County, acted as a liaison agent between growers, processors, Michigan State University and U. S. Department of Agriculture in setting up the project.

[2]Department of horticulture, Michigan State University.

[3]Agricultural engineer, Agricultural Engineering Research Branch, A.R.S., U.S. Department of Agriculture.

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METHOD

A new type of container, the ventilated picking lug,[4] was designed for both picking and the transportation of fruit to processing plants. A thousand lugs of the new type were made up and used in two commercial harvesting operations. Trials conducted during the 1956 season included more than 100,000 pounds of strawberries handled in the special container; a like amount were handled in the conventional manner.

The ventilated-picking-lug method and the carrier-conventional-lug system of handling were compared on the basis of the results obtained. Time, motion and cost studies of all field operations were made. In-the-field and at-the-plant records of fruit quality were kept on 28,255 pounds of berries handled in ventilated picking lugs. Corresponding data were obtained on 30,608 pounds of fruit handled in the conventional manner.

THE VENTILATED PICKING LUG

Fig. 1 shows an isometric drawing of the container used in the trials.[5]

The term "ventilated" is included in the name because the sides, which are lower than the ends, permit air to move freely through a stack of lugs. The term "picking" is used because the container is fitted with a handle which makes it possible for the picker to use the container in much the same way as a carrier is employed. The term "lug" is included because the handle can be detached and the container stacked and used for moving the fruit to the processing plant (Fig. 2). For the sake of brevity, we will hereafter refer to this container as the "V-lug."

The capacity of the V-lugs that were used in the trials was about 10 percent greater than that of the eight 1-quart boxes usually placed in a carrier. Growers who sell strawberries to both processors and fresh fruit markets may wish to use a V-lug designed to accommodate either six or eight 1-quart berry boxes.

In the conventional method of handling berries that are to be processed, each picker receives a carrier containing eight 1-quart boxes. When these have been filled, the worker takes the carrier

[4]The ventilated picking lug used in the trials was designed by David Scott of Northport, Michigan.
[5]The possibility of converting cherry lugs to V-lugs was considered. It was decided, however, that to do so would be both expensive and impractical.

to a check-in station where the fruit contained in the eight 1-quart boxes is poured into a cherry lug.[6]

The picker is credited with the fruit which he has checked in. The empty boxes are replaced in the carrier and the unit is returned to the picker. He then moves back to his row and proceeds as before. The lugs containing strawberries are usually stockpiled for a time and then loaded on a truck and moved to the processing plant.

When V-lugs are used, the first step in the operation is to issue a lug, complete with handle, to each picker. The worker picks the fruit and places it in the lug (Fig. 3). When a lug has been filled, he carries it to a check-in station where he receives credit.[7] He then removes the handle, snaps it into place on an empty V-lug and re-

[6]The capacity of a cherry lug is considerably more than 8 quarts. However, to put more than this amount of fruit in a lug would disturb the convenient one-carrier-one-lug routine commonly used.

[7]Growers who pay on the weight rather than on the volume basis should make sure that the containers checked in are not overfilled.

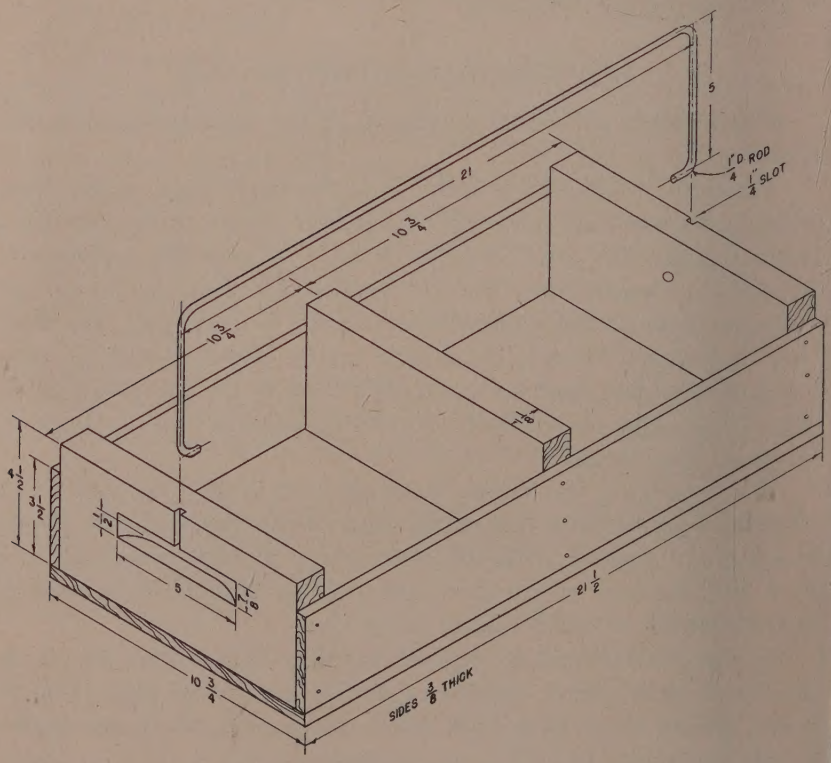

Fig. 1. An isometric drawing of the "V-lug."

Fig. 2. A view of the "V-lug" showing the detachable handle.

Fig. 3. This picker is harvesting into the "V-lug." Of the pickers questioned, 92 percent said that they preferred V-lugs to carriers.

turns to his row and proceeds as before. The filled V-lugs that accumulate at a check-in point are usually stockpiled for a time and then loaded onto a truck and moved to the processing plant.

V-LUGS COST LESS

The V-lugs (without handles) used in the trials cost 46 cents each. The detachable handles cost 17 cents. However, the number of handles used in any particular harvesting operation need not exceed the number of pickers. This means that the cost of the relatively small number of handles needed does not add very much to the average cost of the total number of V-lugs required.

Table 1 shows both the initial and the annual cost of containers required by 100 pickers.[8]

TABLE 1—Costs of picking containers used by a crew of 100

When the conventional method was used				When V-lugs were used			
Item of equipment	Estimated number required	Initial* cost	Annual† cost	Item of equipment	Estimated number required	Initial* cost	Annual† cost
Quart boxes	1,200	$20.00	$20.00	Handles	150	$ 25.50	$ 5.10
Carriers	150	75.00	15.00	.....	.....	.....	.....
Lugs	1,800	900.00	180.00	V-lugs	1,800	828.00	170.70
		$995.00	$215.00			$853.50	175.80

*Quarts were figured at $17 per 1,000 carriers at 50 cents each, lugs at 50 cents each, handles at 17 cents each, and V-lugs at 46 cents each.
†Quart boxes depreciated in 1 year; carriers, lugs, handles and V-lugs in 5 years.

The initial per-picker cost of V-lugs is $1.41 less than that of the quart boxes, carriers and lugs used in the conventional system. The annual per-picker cost of V-lugs is 39 cents less. The savings in container costs are significant, although not as great as some of the other factors to be discussed later.

[8]It was assumed that this crew would consist of 40 adults, 30 teen-agers and 30 children, who would pick 15,000 pounds of fruit per day.

V-LUGS FACILITATE HARVEST

When the conventional method is used, carriers, quart boxes and cherry lugs must be provided.

When V-lugs are used, the distribution of picking containers is greatly simplified. After the picker has the handle, which is issued with the first lug he receives, the V-lug is the only item of equipment that has to be supplied.

Table 2 shows the average time required to perform some of the steps in the harvest operation. Note that the type of container used did not affect the rate at which the berries were harvested.

TABLE 2—Average time required to perform various steps in harvesting

	Number of pounds of fruit picked by an adult in a 10-hour day	Amount of time required per trip to walk to a check-in station	Amount of time required per trip to check in fruit	Number of workers (per 100 pickers) required to check in the fruit
V-lugs	204	40 sec.	15 sec.	1
Carriers	204	40 sec.	45 sec.	3

On the average, the adult pickers who worked for the cooperating growers harvested about 200 pounds of berries in a 10-hour day.[9]

The time required to walk to and from check-in points was about the same, regardless of the type of equipment used.

It took about three times as long to check in berries brought in in carriers as it did those handled in V-lugs. When carriers are used, the checker pours the berries out of the quart boxes into lugs. It was found that a checker could handle 50 carriers per hour as compared to 150 V-lugs. In a field where strawberries are harvested at the rate of 150 carriers per hour, a change to V-lugs would release two checkers for other work.

A check of 200 pickers who used V-lugs revealed that 92 percent of them preferred this container to carriers; 3 percent were indiffer-

[9]Time studies showed that teen-age pickers (11 to 16 years of age inclusive) picked about two-thirds as much fruit as adults. It was found that children (5 to 10 years of age inclusive) picked about one-third as much as adults. This information will enable growers to estimate with reasonable accuracy the amount of fruit that is likely to be picked by a crew made up of individuals of various ages. For example, a crew consisting of 30 adults, 30 teenage youngsters, and 30 children would be equivalent (30 + 20 + 10) to 60 adults. Growers can calculate the approximate number of pounds which any given crew is likely to harvest in a single day by multiplying the number of equivalent adult pickers (as determined above) by the average number of pounds picked. In the example given, the figures would be 60 x 200 or 12,000 pounds.

ent; while 5 percent preferred carriers. When asked why, the latter group of pickers said that it seemed to take more berries to fill a V-lug.

V-LUGS MAKE HANDLING EASIER AND CHEAPER IN THE FIELD

V-lugs do not have to be "air-stacked" in the field. The construction of V-lugs provides for ventilation without special stacking. This characteristic eliminates the time-and space-consuming job of "air-stacking" which is usually considered essential when conventional lugs are used.

The use of V-lugs makes handling and loading easier. The construction of V-lugs makes it possible for the loader to put his hand under the container while it is still in the stack (Fig. 4). This feature makes it possible to handle and load V-lugs comparatively quickly and easily.

Fig. 4. The construction of "V-lugs" not only provides openings for the circulation of air, but makes it possible for workers to place their hands under the lug for easier handling.

Fig. 5. This is a mixed load of conventional lugs and "V-lugs." Note that the amount of space required for four conventional lugs held almost five "V-lugs." The "V-lugs" not only hold more fruit, but they take 17 percent less stacking space.

When V-lugs are used the number of containers required is less. The average weight of the fruit handled in the 2,356 V-lugs that were checked was 13.6 pounds. The corresponding figures for 2,261 cherry lugs, each of which contained the berries transferred from an 8-quart carrier, was 12.25 pounds. On the average, the V-lug contained 1.35 pounds, or about 11 percent more fruit. The use of V-lugs reduced by 11 percent the number of containers used in handling a given quantity of fruit.

IN TRANSIT

More lugs and more fruit can be carried per truckload. The height of V-lugs is 5 inches, compared to 6 inches for cherry lugs. Since the other dimensions are the same, the amount of space saved when V-lugs are used amounts to 17 percent (Fig. 5). As already pointed out, V-lugs hold 1.35 pounds more fruit. When the reduced space and added capacity savings are combined the total transit volume amounts to about 30 percent.

One of the growers who cooperated in the trials found that, with conventional lugs, his truck had a capacity of about 5,400 pounds

of strawberries. The use of V-lugs increased the "strawberry capacity" to about 7,000 pounds. This 1,600-pound difference saved one trip per day to the processing plant, in this case about 30 miles away. The estimated savings amounted to $7 or $8 per day.

V-lugs make at-the-patch palletizing feasible. Unit loads of V-lugs can be stacked on pallets at the patch without loss of space, danger of shifting, or the necessity of restacking at the processing plant. This makes it possible to employ the unit load principle during the entire handling operation.

AT THE PLANT

Palletized lots can be unloaded quickly. Time studies showed that, in one typical case, it took three men 35 minutes to unload 479 lugs of the conventional type. When the same truck arrived with a load of palletized V-lugs, it was unloaded in 10 minutes by a lift truck and one man. The performance ratio was more than 10 to 1.

V-lugs need not be air-stacked. As already pointed out, lugs of the conventional type are usually air-stacked at the processing plant, unless the fruit moves to the processing line immediately. V-lugs make ventilation possible without special stacking.

V-lugs materially reduce handling and storage space requirements. When air-stacked, a standard pallet has a capacity of only 50 conventional lugs. However, the same pallet will accommodate from 96 to 104 V-lugs (Fig. 6). This means that the use of V-lugs reduces by approximately one half the number of pallets required, the number of unit loads handled, and the amount of storage space needed.

V-LUGS HELP MAINTAIN QUALITY

Capping. Capping counts were made on the berries as they passed over the sorting belt. The strawberries contained in 258 V-lugs and 238 conventional lugs (both picked by the same crew, in the same field, on the same day) were checked. The results show that type of container used did not affect the number of caps left on the fruit. In both cases, the number of caps was well within the commonly accepted tolerance.

A crew that developed a tendency to put too many uncapped berries in the lugs could probably be "brought into line" by pouring

Fig. 6. The capacity of a standard pallet is 50 conventional lugs (shown on left) or 96 "V-lugs" (right). The use of V-lugs reduced by about 50 percent the number of pallets required and the number of unit loads handled.

over, in the presence of the picker, an occasional lug chosen at random. If this method did not prove effective, each picker could be asked to place a piece of paper, on which his name appears, in each lug.

Grade of raw product. All of the berries included in the trials were graded by the Federal-State Inspector stationed at the processing plant. The records show that the grades of the fruit moved in V-lugs were from 92 to 96. The comparable figures for berries moved in conventional lugs were 88 to 96. On the average, the V-lugged berries scored 94.7, compared to 92.7 for the conventional lug berries.

In arriving at the grades, the inspector checked caps, color, softness, mold and undeveloped berries. The grade sheets show that the higher grade of the berries handled in V-lugs was due, for the most part, to the slightly smaller percentages of soft, bruised berries than when the fruit was handled in conventional lugs.

Throwouts. Records were kept on the throwouts taken from four separate lots totaling 12,619 pounds of berries handled in V-lugs,

and four corresponding lots (picked by the same pickers in the same field, on the same day) totaling 7,975 pounds handled in conventional lugs. Table 3 compares the results obtained. Note that in all four lots the use of the V-lug reduced the percentage of throwouts. This made the work of the sorters easier and resulted in a product of higher quality.

TABLE 3—The carrier-conventional-lug and the V-lug methods of handling compared on basis of yield of packed fruit

Variety	Carrier-conventional-lug method					V-lug method				
	Lb. of fruit in trial	Lb. sorted out	Percent sorted out	No. 30# tins packed	No. tins packed per 1,000 pounds	Lb. of fruit in trial	Lb. sorted out	Percent sorted out	No. 30# tins packed	No. tins packed per 1,000 pounds
Premier	1,725	44.9	2.6	68.0	39.4	6,507	156.8	2.4	265.5	40.8
Premier	3,328	109.0	3.3	132.5	39.8	1,598	49.0	3.1	64.2	40.2
Catskill	583	33.0	5.6	23.5	40.3	1,350	65.0	4.8	55.0	40.7
Catskill	2,339	110.0	4.7	93.0	39.8	3,164	139.0	4.4	126.5	40.0

Yields of processed product. Yield records were kept on the lots of fruit discussed in the previous section. Results are shown in Table 3. In all cases, the use of V-lugs increased the number of tins packed per 1,000 pounds of raw product. Although the increase is small, it becomes important when large quantities of fruit are processed.

Grade of processed product. Sample cans of both V-lug-handled and conventional-lug-handled strawberries were selected at random, coded, frozen, and held in storage at zero degrees Fahrenheit. Four months later, these cans were opened and graded on the basis of USDA grades by an unbiased inspector.

The results show that while the berries in both lots met A-grade requirements, the V-lug-handled berries averaged 1.75 points higher. The difference in most cases was due to superior "character" and slightly better "color." Both of these quality factors are affected by bruising. This suggests that the conventional method, in which the berries were poured from the quart boxes to lugs, caused more bruising. It may also be true that some berries were bruised by hitting the edges of the quart boxes as they were being filled.

The fact that V-lugs were ventilated may also have been a factor, especially where conditions were such that mold developed.

A BULK BOX DUMPER
For Handling Fruit[1]

By J. H. LEVIN[2] and H. P. GASTON[3]

EARLIER STUDIES[4] have shown that the use of bulk boxes in handling fruit saves time, money, and labor. Both growers and processors have been quick to recognize the advantages of this type of container. It is estimated that during the 1956-57 season, more than a million bushels of Michigan-grown fruit were handled in bulk boxes.

Most of this fruit moved to processing outlets rather than to fresh fruit markets. This was probably due to the fact that the bulk box dumpers available at the beginning of the season caused bruising, which, although not particularly undesirable when the fruit involved was processed immediately, was objectionable when it was sold fresh.

During the 1956-57 packing season, a relatively inexpensive[5] mechanical dumper that caused less bruising than field crate handling methods was developed and tested. It is being manufactured and is now (spring, 1957) readily available. This report describes this bulk box dumper and discusses its operation.

THE BULK BOX DUMPER

The machine consists of a pivoted bulk box "holder" supported by a rigid frame so that a filled box placed upon it can be raised into dumping position by means of hydraulic cylinders. The action of the cylinders is controlled by a three-way valve. As the filled box swings up into dumping position, it comes in contact with a padded cover,

[1]Based on work carried out jointly by the Mechanical Preparation and Conditioning Section of Agricultural Engineering Research Division, A.R.S., U. S. Department of Agriculture; and departments of horticulture and agricultural engineering, Michigan State University, East Lansing.

[2]Agricultural engineer, Agricultural Engineering Research Division, A.R.S., U. S. Department of Agriculture.

[3]Department of horticulture, Michigan State University.

[4]Gaston, H. P., and J. H. Levin (1956). Handling apples in bulk boxes. Mich. Agr. Expt. Sta. Spec. Bul. 409. 19 pp.

[5]Both of the Michigan manufacturers of bulk box dumpers are quoting them at less than $500 (spring, 1957).

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Fig. 1. The lift truck operator is placing a filled box on the dolly which is a part of the dumper. From this point, the box can be pushed onto the box holder manually.

Fig. 2. The operator has opened the valve which activates the hydraulic cylinders and the filled box is swinging into dumping position. The field crate dumper at the end of the line made it possible for the operator to use both field crates and bulk boxes.

a part of which is hinged to allow space for the passage of fruit. During the dumping operation, the movement of this portion of the cover can be regulated by the operator in such a way that the fruit flows out with a minimum amount of bruising.

HOW THE DUMPER OPERATES

The first step in the operation of the bulk box dumper is to place a filled box on the dolly (Fig. 1). The container is then pushed onto

Fig. 3. The box has reached dumping position and the fruit is beginning to flow out. The operator can control the flow by positioning the box and/or applying slight pressure to the hinged portion of the cover. This cut shows a "side" installation. The other dumper observed was installed at the end of the receiving belt. Both positions proved satisfactory.

Fig. 4. An empty box has been lowered to starting position and is being pulled off the box holder by the operator. When the empty is out of the way, the filled box on the dolly is pushed onto the dumper.

the box holder by hand. The operator then opens the valve which activates the hydraulic cylinders and the box begins to swing up (Fig. 2). When the dolly is relieved of the weight of the box, a spring pulls it back into the "ready" position.

When the box reaches dumping position and the fruit begins to come out, the operator controls its flow by positioning the box and regulating the hinged portion of the cover (Fig. 3). When a box has been emptied, it is lowered to starting position and pulled off the box holder (Fig. 4).

Another filled box, which has been placed on the dolly, is then pushed into starting position. This step completes the cycle. The entire dumping operation is performed by one worker.

RESULTS OBTAINED

During the 1956-57 packing season, observations were made on two dumpers, each of which was operated in conjunction with a commercial packing line. These lines were used to grade a total of more than 50,000 bushels of apples. This meant that the dumpers were used practically every day for a period of several months.

Operational data were secured on 72 20-bushel bulk boxes of apples as they passed through the dumpers. Bruise counts were made

on the apples dumped from six bulk boxes (120 bushels) and a like amount of fruit dumped manually from field crates.

CAPACITY

Once a box reached dumping position, it could be emptied as rapidly as the receiving belt moved the fruit away. Both of the dumpers observed were operated in conjunction with grading lines that had capacities of about 100 bushels per hour.

In both cases, the rate at which boxes could be dumped exceeded the capacity of the packing lines. This made it impossible to determine the maximum rate at which the dumpers could be operated. The writers believe, however, that at least 10 boxes (200 bushels) per hour could have been handled effectively.

The time studies show that it took 30 to 40 seconds to lower an empty box, replace it with a full one, and swing it into dumping position. The flow of fruit to the grading line was interrupted during most of this interval. At the rate the boxes were dumped in the packing operations observed (five per hour), the time lost amounted to only about 5 percent and was not proven serious.

Operators who have grading units of unusually large capacity, and who wish to provide an uninterrupted flow of fruit, could achieve the desired result by installing two dumping units. Their operation could be timed so as to provide a continuous flow of fruit.

BRUISING

Bruise counts made on 120 bushels of McIntosh apples showed that the use of a bulk box dumper caused from 40 to 50 percent less bruising than did the field crate method of handling.

The fact that the dumper could be used successfully in handling the soft-fleshed McIntosh variety indicated it can be used to advantage on other dessert varieties.

Although bruising counts were made on only 120 bushels of apples dumped from bulk boxes, the results were confirmed by the returns received from other apples which passed through the machines.

All of the packed fruit moved through regular trade channels to fresh fruit markets where it sold for as much or more than comparable fruit that had been handled in field crates. A considerable number of bushels of the McIntosh apples which passed through one of the bulk box dumpers were put up in cell-pack cartons and brought premium prices.

OPERATION NOT DIFFICULT

Both the up and down motions of the box holder are controlled by a reversible lever which activates the hydraulic mechanism. The flow of fruit can be regulated by positioning the box and/or the amount of pressure applied to the hinged portion of the cover. Any reasonably competent packinghouse worker can learn to operate the dumper after a demonstration and a few minutes of instruction.

SIMPLE AND DEPENDABLE

The dumper has few moving parts, none of which operate at high speed. The construction is rugged, and the machines were used to pack more than 50,000 bushels of fruit without mechanical failure. When examined at the end of the runs, the machines showed no evidence of abnormal wear.

COMMENTS AND CONCLUSIONS

The bulk box dumper described in this paper:

1. Is of sufficient capacity to service most Michigan grader lines.
2. Causes less bruising than results from field crates emptied manually.
3. Is relatively simple and dependable.
4. Is comparatively easy to operate.
5. Presents no unusual service problems.

The bulk box dumper described in this paper should enable growers and packers to use bulk boxes successfully in handling apples destined for the fresh fruit market.

NEW FUNGICIDES AND FUNGICIDE COMBINATIONS FOR TOMATOES

by M. C. STRONG[1]

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

THE CHIEF THREATS to production of canning and market tomatoes are anthracnose, the ripe fruit spot, and the leaf blights—early blight, late blight and Septoria blight. Two or more of these diseases are present every season, causing reductions in yield as well as quality or grade of fruit.

During a previous study of the control of these diseases under variable seasonal conditions, the author reported[2,3] on the effectiveness of several fungicides and fungicide combinations. This paper, a continuation of work previously reported, describes the 1955-1956 tests for tomato disease control. The methods of culture employed and method of obtaining data have been described in previous reports.[4] Southern-grown plants of the Rutgers variety were used in all tests.

1955 TEST

Several tank-mix combinations of various fixed coppers and ziram were compared. Tribasic copper sulfate, cop-o-zink, and tribasic copper sulfate containing 4 percent manganese sulfate were used in combination with Z-C (76 percent zinc dimethyl dithiocarbamate). C-O-C-S (copper oxychloride sulfate) was tried in combination with three formulations of Vancide (zinc, calcium and iron salts). Vancide contains the salts of dimethyl dithiocarbamate plus those of 2-mercaptobenzothiazole. Coro-SDD (40 percent sodium dimethyl dithiocarbamate) was mixed with zinc sulfate to produce ziram; tribasic copper sulfate was added after the reaction had taken place.

[1]The author wishes to thank the several agricultural chemical companies that furnished fungicides and financial assistance for these tests.

[2]Strong, M. C. (1953). Fungicide combinations in tank-mix sprays for tomatoes. Mich. Agr. Expt. Sta. Quart. Bul. 35: 440-449.

[3]Strong, M. C. (1955). Spraying tomatoes with fixed coppers and carbamates. Mich. Agr. Expt. Sta. Quart. Bul. 37: 477-485.

[4]Strong, M. C. (1950). Comparison of fungicidal sprays for the control of tomato blights. Mich. Agr. Expt. Sta. Quart. Bul. 32: 338-347.

ARTICLE 39-56

A combination of tribasic copper sulfate and zineb (Dithane Z-78) was compared with Dithane He-177, the copper salt of nabam.

Captan and a new fungicide, Dyrene (2,4-dichloro-6 (o-chloroanilino) triazine) were also included in the tests.

Plants were set in the field on May 20. Dry soil conditions made irrigation necessary as soon as planting was completed. Six spray applications were made between July 18 and September 15 at 10- to 14-day intervals. Methoxychlor was added to the first two spray applications for insect control. Plots untreated with fungicide received two applications of this insecticide only.

Alternaria and Septoria blights were present from early July, and anthracnose appeared early in August. No late blight occurred. The first picking was made on August 10 and was followed by 10 more.

Rainfall was supplemented by irrigation, so yields were good in spite of a dry season. The culls represented losses mainly from anthracnose, alternaria rot, and sun scald, with some tarnished plant bug injury. The data obtained are summarized in Table 1.

DISCUSSION OF RESULTS

Plots treated with a combination of tribasic copper sulfate plus Z-C produced significantly higher yields and a lower percentage of

TABLE I—Summary of 1955 tomato fungicidal spray trials

Treatment	Formula	Total yield tons per acre	Percentage culls	Percentage defoliation
Control	no treatment	10.6	35.7	79.5
Dithane He 177*	2 lb.—100 gal.	19.7	10.3	17.0
Dyrene†	2 lb.—100 gal.	19.2	10.5	18.5
Captan‡	2 lb—100 gal.	18.1	19.2	40.0
Tribasic copper§ +ZC¶ (tank mix)	2 lb. +1 lb.—100 gal.	20.5	9.8	16.2
Cop-o-zink +ZC (tank mix)§	2 lb. +1 lb.—100 gal.	17.2	14.2	25.3
Tribasic copper (Mn) +ZC (tank mix)§	2 lb. +1 lb.—100 gal.	19.2	14.7	20.0
Tribasic copper +Z78* (tank mix)	2 lb. +1 lb.—100 gal.	19.3	11.6	17.3
COCS¶ +Vancide Z65** (tank mix)	1½ lb. +1 lb.—100 gal.	19.4	10.3	17.4
COCS +Vancide 51** Ca (tank mix)	1½ lb. +2 lb.—100 gal.	18.8	12.7	17.7
COCS +Vancide F995W**(tank mix)	1½ lb. +1 lb.—100 gal.	16.4	14.9	18.9
(Coro SDD +$ZnSO_4$)†† +Tribasci copper (tank mix)	(1 pt. +½ lb.) +2 lb. —100 gal.	18.2	13.8	23.2
Least significant difference (At 1% level)		1.2	3.3	5.5

*Manufactured by Rohm and Haas Company.
†Manufactured by Chemagro Corporation.
‡Manufactured by California Spray Chemical Corporation.
§Manufactured by Tennessee Corporation.
¶Manufactured by Niagara Chemical Division of Food Machinery and Chemical Corporation.
**Manufactured by R. T. Vanderbilt Company.
††Manufactured by Corona Chemical Division of Pittsburg Plate Glass Company.

culls than any of the other combinations of fixed copper and ziram tested, with the exception of C-O-C-S plus Vancide Z-65. The latter combination was almost equal to the former.

Yields and disease control in plots treated with Dithane He-177 were similar to those in plots sprayed with a combination of tribasic copper sulfate plus Dithane Z-78. Both compared very favorably with the better combinations of fixed copper and ziram mentioned above.

The new fungicide Dyrene gave very promising results, comparing favorably with the best fungicides tested. Captan was one of the poorer fungicides in the test, both as to yield and disease control. This fungicide had a tendency to burn the foliage, thus increasing the percentage of defoliation.

All fungicidal spray applications tested resulted in greatly increased yields over no treatment.

1956 TESTS

Since combinations of fixed coppers and carbamates had proved effective in the case of ziram and zineb, it seemed advisable to test some combinations of fixed copper and maneb, each at half the usual strength as with the former combinations. Hence, two new formulations of maneb, Tennam 5 and Tennam 7, and Manzate were compared alone and in combination with a fixed copper. And, since captan at 2 pounds per 100 gallons was inclined to burn tomato foliage, it was used at 1 pound per 100 gallons in combination with a fixed copper, also at one-half the usual concentration.

Two Vancide formulations were compared alone and plus C-O-C-S. These were also compared with Zerlate alone and in combination with C-O-C-S. The new material, Dyrene, was also included in the tests.

The weather during the 1956 growing season was unusual. A wet spring made early planting impossible. Plants were set May 30. Five spray applications were made at 10- to 14-day intervals between July 17 and September 8. Methoxychlor was added to the first two spray applications for insect control. Plots untreated with fungicides received two applications of methoxychlor only.

The first half of the summer was cool and wet. Early blight and Septoria blight both made a good start and spread over the untreated plots. Although the latter part of the season was dry, irrigation was not used. Late blight did not occur, and anthracnose infection was very slight.

Late planting and cool weather delayed harvest. The first picking was made August 17 and was followed by seven more. As a result of the short picking season, yields were lighter than usual. Table 2 shows total marketable yield and does not include culls. No data on culls are shown because most resulted from soil rot early in the season and from frost injury after September 20 when a light, but not killing, frost occurred.

TABLE 2—Summary of 1956 tomato fungicidal spray trials

Treatment	Formula	Total marketable yield tons per acre	Percentage defoliation Sept. 14, 1956
Control	no treatment	7.8	71.2
Vancide Z65*	2 lb.—100 gal.	12.9	34.1
Vancide Z65 + COCS†	1 lb. + 1½ lb.—100 gal.	13.9	24.0
Vancide M*	2 lb. —100 gal.	12.0	39.5
Vancide M + COCS	1 lb. + 1½ lb.—100 gal.	12.9	31.1
Dyrene‡	2 lb.—100 gal.	13.7	30.3
Tennam 5§	2 lb.—100 gal.	12.7	38.2
Tennam 5 + Cu Mn‡§	1 lb. + 2 lb.—100 gal.	13.3	28.1
Tennam 7§	2 lb. 100 gal.	13.2	35.3
Tennam 7 + Cu Zn‡§	1 lb + 2 lb.—100 gal.	14.1	28.0
Zerlate¶	2 lb.—100 gal.	12.5	43.7
Zerlate + COCS	1 lb. + 1½ lb.—100 gal.	13.9	29.1
Manzate¶	2 lb.—100 gal.	13.1	36.2
Manzate + Cu Mn	1 lb. + 2 lb.—100 gal.	12.8	26.3
Captan**	2 lb.—100 gal.	11.3	50.5
Captan + Cu Mn	1 lb. + 2 lb.—100 gal.	11.0	49.0
Less significant difference (at 1% level)		.8	7.1

*Manufactured by R. T. Vanderbilt Company.
†Manufactured by Niagara Chemical Division of Food Machinery and Chemical Corporation.
‡Manufactured by Chemagro Corporation.
§Manufactured by Tennessee Corporation.
¶Manufactured by E. I. duPont and Company.
**Manufactured by California Spray Chemical Corporation.

DISCUSSION OF RESULTS

All the treatments tested increased yield and decreased defoliation, compared to untreated controls.

Vancide Z-65 was superior to Vancide M and Zerlate. Vancide Z-65 plus C-O-C-S was significantly better than Vancide Z-65 alone or Vancide M plus C-O-C-S, and it was equal in effectiveness to Zerlate plus C-O-C-S. The latter was significantly better than Zerlate alone.

Dyrene was again very promising, both as to marketable yield and disease control.

The three formulations of maneb tested (Tennam 5, Tennam 7 and Manzate) compared very favorably as to yield and percentage

Fig. 1. Tomato plots sprayed with various fungicides compared to an untreated plot.

Upper left, sprayed with C-O-C-S plus Vancide Z-65.
Upper right, sprayed with tribasic copper sulfate plus Z-C.
Lower left, sprayed with Dyrene.
Lower right, untreated.

Fig. 2. Tomato plots sprayed with various fungicides compared to an untreated plot.

Upper left, sprayed with Tennam 7.
Upper right, sprayed with Tennam 7 plus tribasic copper sulfate.
Lower left, sprayed with Tennam 5.
Lower right, untreated.

of defoliation. However, the results with the combinations of these three formulations with a fixed copper were somewhat contradictory.

The combination of Tennam 7 plus tribasic copper sulfate containing 4 percent zinc sulfate resulted in a significant increase both in yield and in disease control over Tennam 7 alone. Compared to Tennam 5 alone, the combination of Tennam 5 plus tribasic copper sulfate containing 4 percent manganese sulfate resulted in a significant increase in disease control and an increase in yield, but it was not great enough to be significant. Compared to Manzate alone, the combination of Manzate plus tribasic copper sulfate containing 4 percent manganese sulfate resulted in a significant increase in disease control and a decrease in yield, but it was not enough to be significant.

Captan and captan in combination with fixed copper were equally poor as tomato fungicides.

CONCLUSIONS

Even in seasons when climatic conditions are not particularly favorable for the development of the leaf blights or anthracnose, a good spray program can bring about a 50 percent or better increase in marketable yield.

Combination spray treatments using ziram or zineb with fixed copper, each at one-half the recommended concentration, continue to give good control of anthracnose, early blight and Septoria blight. If late blight threatens, increase the fixed copper portion of the spray to the usual recommendation (2 pounds of metalic copper to 100 gallons). If it could be more easily manufactured, copper ethylenebis dithiocarbamate might prove to be the most effective fungicide for tomatoes. This is indicated by tests of Dithane He-177.

Dyrene offers good control of anthracnose, early blight and Septoria blight; but it has not been tested here against late blight. Until further tests indicate the efficacy of Dyrene against late blight, it cannot be fully recommended.

Captan, while an excellent fungicide on many crops, is not recommended for tomatoes.

Maneb is recommended for tomato disease control. Tennam 5, Tennam 7 and Manzate are equally effective. Tests of this fungicide in combination with others will be continued in the hope that improved performance may be obtained.

HATCHING POWER OF PUREBRED VS. CROSSBRED CHICK EMBRYOS

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MANY HATCHERY OPERATORS believe that eggs from "crossbred" matings hatch better than those from "purebred" matings. This theory is supported by the currently popular "hybrid vigor" doctrine.

This is a report of another test of the "crossbred" theory with 128 different pedigreed hens which were mated successively to two or more individual males. There were 220 families of embryos involved. One male of each pair of sires was of the same breed as the hen in 92 cases. The other males of the pairs were of a different breed, but all were pedigreed. Forty-eight pairs of males and five unpaired (101 in all) were used in the test. There were 2,227 fertile eggs set and 1,916 chicks hatched. Very nearly the same proportions of purebred and crossbred chicks were produced.

PEDIGREE BREEDING PRACTICE PROVIDES A CRITICAL TEST

It should be a fairly simple matter to test the "hybrid vigor" theory with hens. They can be mated alternately with two or more different kinds of males during a single hatching season. The hatching power (i.e., vigor of embryo chicks in eggs) from the different males can be measured under very nearly the same "environmental" conditions. Once an egg is laid, it is a closed package of food for embryonic development for the entire 3 weeks of the growth (incubation) period.

Individual hens can be relied on to supply a uniform environment for each embryo chick inside their eggs, regardless of which male provides the microscopic sperm for fertility. Uniform incubation conditions can be provided by normal incubator operation.

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Although the numbers of chromosomes in eggs are assumed to be nearly equal from sires and dams, the embryo chick must grow within a restricted environment provided almost entirely by the dam.

PROCEDURE

The rotation of males in pens for recorded intervals of time, in days, is routine practice in the breeding project from which these data were obtained. There were two important reasons for the practice: (1) accurate pedigreeing was important for all purposes of the project; and (2) restricted space allocations have made it necessary to get several different progenies from each pen of birds for each of the past 3 years.

SOURCE OF DATA

The data presented and analyzed herein were taken from routine pedigree hatching records of research project number 266 of the Michigan Experiment Station. The fact that the data are from the three different years, 1954, 1955, and 1956, does not affect comparability. The comparisons were made between sires "within hens" and within years. Between-year differences, if they existed, could not affect the comparisons, because both the male and female populations were different each year.

INCUBATION METHODS

Incubation procedures are generally so well-known that they are about as standard as automatic "air conditioning" processes can be. The same make and model of incubator was used for all 3 years of this study. The fact that eggs were laid and set at different times did not affect the comparability of the "embryonic environment" seriously.

Eggs were usually accumulated in "sets" and stored in a common room at temperatures of 65° to 70° F. until set. After setting, they were put into incubators which were operated at thermostatically controlled optimum temperatures.

PEDIGREE METHODS

Pedigree procedures are so well-standardized in our project that the ancestry of each embryo chick was determined with reasonable accuracy.

SOME PREVIOUS INVESTIGATIONS

Several investigators have reported that "crossmating" improves hatchability. Some attribute this improvement to the "hybrid vigor" doctrine (Hutt and Cole, 1951 and 1952; and Champion, 1956). In 1930, the writer (Henderson, 1930) found little difference in growth rate between purebred and crossbred chick embryos.

More recently, (Henderson, 1951), our results showed statistically that crossbreeding had a slightly depressing effect on hatchability of embryos from identical hens. Furthermore, the hen tended to have more influence on the hatching power of her embryos than did their sires. This latter finding was at variance with reports of Waters (1944) and Champion (1956). Both these studies were made from small samples of populations of a single breed, the Single Comb White Leghorn. They may not be comparable to the present report.

The use of "strain" crosses within a breed to demonstrate a "hybrid" theory seems somewhat illogical at first glance, because there could be as much variability within a "strain" as there is within a "breed." Although the experimental reports are conflicting, there is one area of agreement: "crossmating" has very little effect on hatching power.

BREEDING STOCK

The stock from which eggs were obtained consisted of a total of 48 pens (3-year data) and 128 hens selected at "random" from among 11 "breeds" and/or definite "strains."

The term "random" should be qualified somewhat. Randomization occurred in this way: Only those hens which happened to have been mated to two or more separated males during the same hatching season and which had five or more fertile eggs set were included. There were many other hens in the same matings which did not happen to have at least five eggs set. Such hens might be included in some massed "strain" or "breed" average data, but they were not considered suitable for the final statistical analyses for this particular report.

The breeds were also selected by the same "random" method. They were predominantly Cornish or Cornish crosses; but three Mediterranean varieties, White, Red and Buff Leghorns, were represented. One American class breed, the White Rock, was included. There were three Standardbred varieties of Cornish—the Darks, White Laced

Reds and Whites. There were four synthetic varieties of Cornish crosses—the Silver Laced Cornish, Red Cornish, Red Laced Silver Cornish, and Red and White Barred Cornish.

The diversity of "breeds" provided a representative sample of poultry populations in general and a more "random" sample of hatching performance potential than would be obtainable from within a single strain or breed.

MATING METHODS

No particular sequence of rotating males was followed. In order to get maximum utilization of the meager space allocated to the project, from two to four different males were used in each pen each year. Ten to fourteen days were allowed to elapse after a change of males before crediting progeny to the most recent male.

Only one male was permitted in each pen during each mating period. In some cases, a purebred mating was made at the first of the season but this order was reversed in many cases. Routine pedigree mating and hatching records were kept at all times.

RESULTS

The combined total hatching results are summarized first in the customary manner, Table 1. Many hatching experimental reports have been summarized in this manner in the past, especially when individual hatching performances were unknown. That this method of summarization may lead to false conclusions will be shown later.

A more valid experimental method is to determine the hatching performances of individual hens under both systems of mating; i.e., "pure" vs. "cross" (Table 2). This "paired" method of tabulation makes it possible to determine how often the hatching power of individual hens varied with the kind of mating. Statistically, this might be called a "within-hens" comparison. It permits the use of the Chi-square technique of statistical analysis with each hen.

If properly computed, the Chi-square method yields the most valid estimate of the probability of a significant variation between the two "systems" of mating. For proper computation, it is important to use the average of the two hatches within each hen by the two different males to establish the "expected" value.

If the average of the entire group of hens is used to compute the "expected" number, a false Chi-square will be obtained because of

the tendency of hens to hatch at the same rate regardless of the way they have been mated. For example, hen number "X" may hatch 100 percent by both males. Both her hatches differ from the average (86 percent) and would therefore contribute to a Chi-square value when, actually, there is no difference between the two matings in her case.

The direct comparison "within hens" is made with only those hens which were mated in succession to each of a pair of males (Table 2). There is a slight difference in the percentage hatch of the totals between Tables 1 and 2, but the difference between the two classes of sires happens to be about the same in this case. A substantial number of eggs from each hen were set from both kinds of matings; i.e., pure and crossmating.

TABLE 1—Hatching results from purebred vs. crossbred matings

Kind of mating	No. males (sires)	No. females (dams)	Fertile eggs	Chicks hatched	Av. %*
Pure.....	52	96	1,010	885	88
Cross.....	53	128	1,217	1,031	85
Total.....	119	222	2,227	1,916	86

*Reasons why this might be statistically but not biologically valid for comparison are given in text.

Table 1 was compiled by including all eggs set from all hens in each kind of mating, regardless of whether each hen had eggs fertilized by both purebred and crossbred sires or not. Table 2 was compiled by including only the eggs from those hens which had eggs set from both kinds of males but with little restriction as to the number of eggs fertilized by either class of males. The method of Table 2 is somewhat more valid than that of Table 1. It might still be misleading because of differences in numbers of eggs fertilized by each kind of mating; i.e., pure vs. cross, and the percentage criteria of comparison.

TABLE 2—Hatching results from pairs of pure and crossbred matings

Kind of mating	No. males (sires)	No. females (dams)	Fertile eggs	Chicks hatched	Av. %*
Pure.....	48	92	970	848	87
Cross.....	48	92	888	749	84
Total.....	...	...	1,858	1,597	86

*Reasons why this might be statistically but not biologically valid for comparison are given in text.

IMPORTANCE OF PERTINENT STATISTICAL METHODS

One kind of statistical procedure (Analysis of Variance) could be applied to the total data of both Tables 1 and 2 without protest from most statisticians or the average commercial hatchery operator. The fallacy might not be in the Analysis of Variance procedure itself. The demonstration of Analysis of Variance technique from the totals might be impressive enough for most purposes but the conclusion would be biologically invalid.

A little common sense reflection should suggest some of the hidden bias in mass averages such as the data of Tables 1 and 2. Most everyone knows that variation in performance between individuals (both males and females) is normal. Therefore, we should test as many different individuals as possible.

Normally, hens do not lay the same number of eggs during any single egg-saving period (7 to 14 days). The hen which lays 14 eggs has an advantage over one which lays five eggs. One egg failing to hatch out of five produces a performance percentage of 80 percent, whereas failure of a single egg out of 14 eggs yields a hatching percentage of about 93 percent. No one knows, of course, whether the next nine eggs of the "five-egg hen" might have hatched or not, regardless of which male might have fertilized them. Both hens could be equal in hatching power.

Other more extreme differences may exist, such as a hen which had one egg set which hatched, i.e., 100 percent. She should be excluded, of course. One hen in this experiment, mated to two different males, hatched 47 chicks from 47 eggs during the year (also 100 percent). Just where to draw the line excluding records from data is, in part, a matter of technical judgment. In this test, a minimum of five eggs from a hen was tolerated because of anticipated statistical methods; i.e., the Chi-square test. Such a test, if properly applied, equalizes numbers between individuals.

For some purposes, individual performance may be equalized by percentages, especially if the numbers are large enough. Remember that a single egg difference among 10 eggs fixes variability by increments of 10 percent, whereas one egg difference among 100 eggs yields an increment of variation of only 1 percent.

It should be clear, then, that hidden bias can exist in massed flock averages of "strains" of hens, pens, or mating averages. At least two valid methods of statistical analyses which compensate for

difference in numbers are available for testing hatchability data. One was adapted by the writer (Henderson, 1951) from Snedecor (1937); the other is the well-known Chi-square technique introduced in 1900 by Pearson and cited in many elementary statistic textbooks.

To compensate precisely for the unavoidable differences in numbers of eggs from each hen by each mating, statistical significance was finally determined by computing the sum of the Chi-squares from individual hens (i.e., "within hens"), instead of the Chi-square from the totals in Table 2.

A Chi-square test of the difference between individual hens and sires on the hatching power of purebred and crossbred embryos in this experiment showed that the difference was not significant. The chances of an actual depressing influence on hatching power of crossbred embryos were not measurable within the limits of probability. This is contrary to the popular "hybrid vigor" doctrine.

THE RELATIVE INFLUENCE OF THE DAM ON HATCHING POWER

A casual examination of the hatching performance of the individual hens when "pure" and when crossmated showed the following results: Hatchability was enhanced 25 times and depressed 44 times by crossmating. There was no difference in 23 cases out of the 92 hens. There was an apparent tendency of hens to hatch well or poorly, regardless of the way they were mated. The correlation between purebred and crossbreds within the hens was positive (.46) and highly significant beyond the conventional one chance in 100 criteria ($P = .01$).

SUMMARY

The results of this study confirm an earlier report of Henderson (1951) that crossmating actually slightly reduced hatching power of chick embryos. They also confirm the evidence of the same study that the hatching abilities of embryos are influenced decidedly more, on the average, by the hen via the kind of eggs she lays than by the male which contributes the sperm and practically an equal number of chromosomes and any lethal genes he may have at fertilization.

The correlation was high (.46). Reasons for a special method of statistical analysis (the comparison of pairs of sires within individual hens by means of the Chi-square test) were shown.

LITERATURE CITED

Champion, L. R. (1956). The performance of two strains of Leghorns in inter and intrastrain matings. Mich. Agr. Expt. Sta. Quart. Bul. 39: 321-326.

Henderson, E. W. (1930). The influence of temperature and breeding upon the rate of growth of chick embryos. Mo. Agr. Expt. Sta. Res. Bul. 149. 47 pp.

———————— (1951). Hatchability of purebred and crossbred chick embryos. Mich. Agr. Expt. Sta. Quart. Bul. 34: 83-88.

Hutt, F. B., and R. K. Cole (1951). Heterosis in an interstrain cross of White Leghorns. Poul. Sci. 30: 918.

———————— (1952). Heterosis in an interstrain cross of White Leghorns. Poul. Sci. 31: 365-374.

Pearson, Karl (1900). Philosophical Magazine, Series 5, 50: 157.

Snedecor, G. W. (1937). *Statistical Methods.* Collegiate Press, Ames. 341 pp.

Waters, N. F. (1944). The hatchability of chicken eggs as influenced by diallel crossing. Poul. Sci. 23: 495-496.

PROFILE OF LANSING CONSUMERS[1]

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WHAT ARE THE CHARACTERISTICS of Lansing, Michigan, families? On which day of the week do they buy most of their groceries? How many buy at the city market? How many save trading stamps?

A random sample of 2,103 Lansing households answered these and other questions in a survey during the spring of 1956. This summary of their responses provides a general picture of some of the consumer and family characteristics of this urban population of about 90,000 people.

CONSUMER CHARACTERISTICS

DAY OF WEEK

In response to the question "On which day did you buy most of your food last week?":

1 percent said Sunday[2].
3 percent said Monday.
2 percent said Tuesday.
21 percent said Wednesday.
11 percent said Thursday.
35 percent said Friday.
27 percent said Saturday.

Thus, of the six regular shopping days, about 84 percent of the families reported buying most of their groceries on Wednesday, Friday and Saturday; more families bought on each of these days than on the other three days combined.

[1]M.S.U. Consumer Panel Report No. 41, March 1957.

[2]Only about one-half of 1 percent said Sunday, but all figures were rounded to the nearest full percentage.

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WHO DOES THE BUYING?

The homemaker is still the major food buyer for most families, but the husband gets in on the major shopping trip for almost 30 percent of the families. In response to the question "Which member of your household did most of the grocery shopping for your family last week?":

68 percent said the homemaker (female head).
16 percent said the husband (male head).
13 percent said the husband and wife shop together.
3 percent said some other member of the household.

FOOD EXPENDITURES

How much did these households spend for food? The question asked was "About how much did your household spend for food per week in 1955, not including money spent for meals eaten away from home?" The average for all families reporting was $21.60. About 14 percent said they spent less than $12.00 per week; 17 percent between $12.00 and $15.99; 25 percent between $16.00 and $21.99; 22 percent between $22.00 and $29.99; and 22 percent $30.00 or more.

RETAIL SOURCES

A rough estimate of the number of different stores from which families bought meat was determined by asking the respondents to check from which of nine retail meat sources they purchased meat the previous week. Seventy-nine percent of the families reported purchases of meat from only one of these nine sources; 16 percent from two sources; 3 percent from 3 sources; and 2 percent reported buying no meat during the "past 7 days".

These sources included four national or regional grocery chains (which together accounted for 33 percent of meat expenditure); a local chain; a local independent grocers' cooperative group and a two-store meat market (who together accounted for 27 percent of meat expenditures); all other grocery stores and meat markets as a group (accounting for 33 percent of meat expenditures); and, finally, all other sources such as locker plants, farmers market, etc. (which accounted for 7 percent of reported expenditures for meats).

MEAT SOURCES

Another question was "Did you buy most of your meat last week from the same store where you bought most of your meat the week

before?" About 15 percent of the families said that they did not. In other words, on successive weeks about 15 percent of the families made their major meat purchases at different stores.

TRADING STAMPS

About 90 percent of all families reported that they save trading stamps. Sixty-five percent reported redeeming trading stamps last year. Seventy-four percent of the families reported that they purchased most of their food the previous week from a grocery store giving trading stamps.

HOME GARDENING, CANNING AND FREEZING

About 22 percent of the households reported they had a vegetable garden in 1955, and 44 percent said they did some home canning of fruits and vegetables during the year. About 16 percent both canned and gardened and about one-half did neither.

About 15 percent of the families reported they had a home freezer with capacity of 5 cubic feet or more. Less than 1 percent rented frozen food lockers.

Half of the families reported buying at the Lansing City Market during 1955.

FAMILY CHARACTERISTICS

RADIO AND TELEVISION OWNERS

Almost as many households had television sets as had radios. About 94 percent reported that their radios were in working order, compared with 91 percent who had television sets.

EMPLOYMENT

About 30 percent of all households had more than one person employed more than one-third of the time outside of the home. About 10 percent had no member employed[3]. About 25 percent of the households had two or more members employed, including the homemaker. Since about 10 percent of the households were single-person units, this indicates that at least 28 percent of the wives were employed outside the home.

[3]This does not mean that 10 percent of the households have unemployed members by usual definition, since most of these households with no member employed would have no adult male members, or the adult male would be of retirement age.

SEX AND AGE OF HEAD OF HOUSEHOLD

About 14 percent of the households reported no adult male member, and 3 percent said the household had no adult female member. Table 1 gives the age distribution of the male and female heads of households.

TABLE 1—Age distribution of heads of households, M.S.U. Consumer Panel members, 1956

Age	Percent of female heads of households	Percent of male heads of households
30 or under	22	18
31-45	36	37
46-60	27	28
over 60	15	17

EDUCATION

About 39 percent of the homemakers (female heads of households) and 44 percent of the husbands (male heads of households) reported formal education of less than high school. More women than men had completed high school, but more men had 2 or more years of college training. Table 2 gives the educational distribution for the male and female heads of households.

TABLE 2—Educational distribution of heads of households, M.S.U. Consumer Panel members, 1956

Years of formal education	Percent of female heads of households	Percent of male heads of households
0-8	17	22
9-11	22	22
12-13	44	33
14 or more	17	23

SIZE OF HOUSEHOLD

The average size of household was 3.2. There were more two-person households than any other size, but a large proportion of the

city's population lived in households of four members. Table 3 shows the percent of households of each size and the percent of the population living in these households.

Table 3—Size of households, M.S.U. Consumer Panel members, 1956

Number of persons	Percent of households	Percent of people
1	10	3
2	32	20
3	19	18
4	18	22
5	12	19
6	5	9
7 or more	4	9

INCOME

Almost half the families reported disposable incomes (i.e., income after federal income taxes) of between $4,000 and $7,000 for the year 1955. Almost twice as many families reported incomes below $2,000 as reported incomes over $10,000. Table 4 shows the percentage of families reporting various incomes for 1955.

TABLE 4—Income of families, M.S.U. Consumer Panel members, 1955

Income	Percent of families in that income bracket
$2,000 and under	11
2,001-4,000	21
4,001-5,400	26
5,401-7,000	21
7,001-9,999	15
10,000 and over	6

WHO SAVES TRADING STAMPS?[1]

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TRADING STAMPS are big business. In 1956, trading stamps were given with the sale of over $30,000,000,000 worth of goods and services. The retail value of stamp premiums totaled more than $1;000,-000,000[2]. Merchants adopt trading stamps because they believe it will increase sales volume or at least keep them from losing sales to other retailers who offer stamp plans.

Trading stamps have become a controversial issue. Several states have attempted to make their use illegal. Unfortunately, there is little factual information concerning stamp saving and redemption and the effects of stamp plans on costs.

To learn something of the importance of trading stamps to consumers and to determine the extent of stamp saving, several questions concerning trading stamps were included in a recent survey. This survey was of a random sample of over 2,000 families of Lansing, Michigan, conducted during the spring of 1956. Almost 90 percent of the families reported that they saved trading stamps during the "past year." Many saved more than one kind of stamp as is shown by the following tabulation:

11 percent did not save stamps during the "past year."
32 percent saved only one kind of trading stamps.
29 percent saved two kinds.
14 percent saved three kinds.
8 percent saved four kinds.
4 percent saved five kinds.
2 percent saved between six and nine different kinds of stamps.

[1]M.S.U. Consumer Panel Report No. 40, February 1957.
[2]Howell, L. D. (1957). Use of trading stamps in marketing food. U. S. Dept. Agr., Agr. Marketing 2(1): 6.

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The number of different kinds of stamps which were redeemed during the "past year" was markedly different from the number saved:

35 percent reported redeeming no stamps during the "past year."
47 percent redeemed one kind of stamp.
16 percent redeemed two kinds.
2 percent redeemed three or more kinds of stamps.

While many families saved several types of trading stamps, there was a very great difference in the popularity of the different stamps. This is shown by the following tabulation of all families reporting:

72 percent saved and 49 percent redeemed the most popular stamp.

30 percent saved and 13 percent redeemed the second most popular stamp.

26 percent saved and 4 percent redeemed the third most popular stamp.

19 percent saved and 3 percent redeemed the fourth most popular stamp.

13 percent saved and 4 percent redeemed the fifth most popular stamp.

9 percent saved and 6 percent redeemed the sixth most popular stamp.

3 percent saved and 1 percent redeemed the seventh most popular stamp.

2 percent saved and 1 percent redeemed the eighth most popular stamp.

7 percent saved and 4 percent redeemed some other kind of stamps.

One of the questions was, "Does the grocery store where you buy most of your groceries give trading stamps?" Seventy-four percent of the families answered "yes."

About 18 percent of the families buying most of their groceries at stores giving trading stamps (about 13 percent of all the families) said they would change to another store if the stamps were discontinued. Based upon these data, the average grocer now giving trading stamps could expect to lose about 18 percent of his customers if he discontinued stamps without substituting another means of attracting customers.

The families were divided into four groups indicating the degree

of importance or acceptance of trading stamps by the family. This characteristic was then related to certain socio-economic characteristics of the families. The four groups were as follows:

Group I did not save stamps.

Group II saved stamps, but grocery store where most groceries are purchased did not give stamps.

Group III saved stamps, grocery gave stamps, but they would not change store if stamps were discontinued.

Group IV would change grocery store if store where they bought most of their groceries discontinued stamps.

TABLE 1—Differences in percent of family acceptance of trading stamps, related to family characteristics

	Groups			
Characteristic	I	II	III	IV
Total sample	11%	19%	57%	13%
Number in family:				
1 member	28	26	38	8
2 members	11	18	59	12
3 and 4 members	7	17	61	15
5 or more members	7	23	57	13
Years of formal education of the female head of household:				
0-8	14	20	55	11
9-11	13	18	57	12
12-13	8	20	58	14
14 or more	6	20	59	15
No female head	44	14	34	8
Age of female head of household:				
30 or under	7	19	56	18
31-45	7	18	63	12
46-60	9	22	56	13
Over 60	20	21	50	9
No female head	44	14	34	8
Size of food bill (weekly):				
Less than $11.99	22	9	48	21
12.00-15.99	9	16	58	17
16.00-21.99	6	15	60	19
22.00-29.99	10	11	61	18
30.00-over	7	16	56	21
Last year family income:				
$2,000 and under	28	16	50	6
2,100-4,000	10	19	56	15
4,100-5,400	7	19	59	15
5,401-7,000	7	17	64	12
7,000-10,000	7	21	57	15
Over $10,000	13	22	54	11

Table 1 shows the differences in the percent of families in each of these groups when related to five important family characteristics.

Statistical tests indicated that the differences in the distribution of these characteristics between groups were significant. For each of the five characteristics above, the probability of getting such differences in distribution pattern for the four groups was less than one chance in 1,000.[3]

In general, these data indicate that the families least influenced by stamp plans are:[4]

a. Those with one member.
b. Those with less formal education.
c. Those with older homemakers.
d. Those with small food bills.
e. Those with low incomes.
f. Those which include no male head.

Note that a larger proportion of the families with incomes of $10,000 and over save stamps and would change grocery stores as a result of discontinuation of stamps than would families with incomes of $2,000 or less. Also, a larger percentage of homemakers with some college education save stamps and would change grocery stores as a result of discontinuation of stamps than would those with less education.

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[3]Based upon Chi-square tests using the actual numbers. The five tests indicated a significance level of .001.

[4]When the families were divided according to the number of different kinds of stamps saved and redeemed as an indication of the acceptance of stamps, the same general relationships were indicated as shown by these data.

The families were divided into five groups: (1) those not saving stamps; (2) those saving stamps but redeeming none; (3) those saving and redeeming one kind of stamp; (4) those saving two kinds and redeeming one or two kinds; and (5) those saving three or more kinds and redeeming at least one kind of stamp

Chi-square tests again indicated significantly different distributions when related to age and education of the homemaker, size of family and family income. Only 15 percent of the homemakers with 8 years or less education were in group 5, compared with 29 percent of those with some college education. Similarly, 21 percent of all families were in group 5, but only 7 percent of those homemakers over 60 years old were in this group.

A COMPARISON OF SEVERAL METHODS OF ESTIMATING TOTAL SOLIDS CONTENT OF INDIVIDUAL COW'S MILK

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INCREASING IMPORTANCE is being placed on total solids produced by individual cows, both from the consideration of genetically increasing the production of total solids and determining such composition.

Methods for estimating the total solids content of milk from the fat content and lactometer reading have been reviewed by Hermann (1954). Ideally, a gravimetric method would be selected for this purpose. However, such methods are both time-consuming and expensive. A simpler, yet relatively accurate, test is needed, particularly to measure the composition of many samples of milk. Quevenne and BDI lactometers, together with several formulas for estimating the total solids content, were used in this study.

EXPERIMENTAL

Individual cow's milk was tested for total solids content gravimetrically by the Mojonnier method and by measuring the specific gravity with various lactometers. Fat content was determined by the Babcock method; solids-not-fat content was estimated as the difference between total solids (Mojonnier) and fat.

The accuracy of the lactometer determinations compared with gravimetric determinations of total solids on the same samples of milk was measured. A portion of the data was grouped by herds to compare equations for predicting TS (total solids) and SNF (solids-not-fat) from F (fat).

The data were collected between November 1953 and June 1955. In general, the sampling procedure was as indicated by Specht et al.

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(1956). Most samples were from two groups of Jersey cows (13 and 24 cows), but samples from three Holsteins were also included.

RESULTS AND DISCUSSION

Correlation Between Duplicate Gravimetric Determinations On the Same Milk Sample

Duplicate gravimetric determinations for total solids content were made on 974 milk samples. The fat content of these samples, as determined by the Babcock method, averaged 5.5 percent and ranged from 1.5 to 8.5 percent. The total solids content averaged 14.98 percent and ranged from 8.95 to 20.19 percent. An overall correlation of 0.996 was calculated between the duplicate determinations on the same sample.

When these samples were grouped according to percent fat content, the intrafat level correlation was 0.979, indicating that fat level had little effect on the accuracy of duplicate determinations. Correlations of this magnitude indicate that duplicate gravimetric determinations are not necessary to estimate accurately total solids content of milk.

Because of the accuracy of the method and the relatively high cost, duplicate gravimetric determinations have been discontinued. This program seems warranted for laboratories using such procedures.

Relations Between a Single Gravimetric Determination and Several Lactometer Determinations

Two different lactometers were available during the course of this study. The formulas for estimating total solids using the lactometers are presented in Table 1.

The average total solids computed from the Quevenne and BDI lactometer readings, compared with a single gravimetric total solids determination, are presented in Table 2. Except for formulas 3 and 4, the average total solids from the various formulas differ significantly from the gravimetrically measured total solids.

Correlations between the total solids calculated from each formula, the total solids measured gravimetrically, and the standard errors of estimate are also given in Table 2. The "total" correlations indicate that, when fat level is ignored, there is almost perfect association between the lactometer and gravimetric methods. The "intrafat

TABLE 1—Formulas used for estimating total solids (TS) content of milk from its fat (F) content and its lactometer (L) reading

Source	Type of lactometer*	Formula	
		No.	Equation
Babcock (1892)	Quevenne†	(1)	$TS = 1.1842F + 0.2631L$
Babcock (1892)	Quevenne	(2)	$= 1.2F + 0.25L$
Richmond et al. (1942)	Quevenne	(3)	$= 1.2F + 0.25L + 0.14$
Overman et al. (1925)	Quevenne	(4)	$= 1.2F + 0.25L + 0.173$
Hermann et al. (1954)	Quevenne	(5)	$= 1.219F + 0.237L + 0.307$
Whittier (1954)	BDI‡	(6)	$= 1.2624F + \frac{273L}{L+1000}$
Whittier (1954)	BDI	(7)	$= 1.33F + \frac{273L}{L+1000} - 0.31$
Watson (1956)	BDI	(8)	$= 1.33F + \frac{273L}{L+1000} - 0.40$

*Lactometers were standardized with skimmed milk of known density at the designated observation temperatures.

†Quevenne Lactometer—Central Scientific Co., Chicago. Calibrated in 0.1 lactometer degrees and read at 60 degrees F.

‡BDI Lactometer—Taylor Lactometer, Watson pattern—Taylor Instrument Co., Rochester, N. Y. Calibrated in 0.2 lactometer degrees and read at 102 degrees F.

level" correlations indicate that this association is not so close when the methods are compared at various fat levels.

For milk samples similar to those in this study, the following recommendations seem warranted: (a) Formulas 3 and 4 for the Quevenne lactometer are the most accurate of the formulas considered for estimating total solids; (b) modification of formula 8 by changing the constant to 0.60 would render it not significantly different from the gravimetric results and therefore useful for measuring total solids with the BDI lactometer. Note, that while acceptability of a formula was based on the difference between the average total solids (and variability) for that formula and the gravimetric measurements, the actual difference of less than 2 percent may have practical implications, since a 2 percent error in the Babcock reading would be difficult to ascertain and since the Babcock results are combined with lactometer readings to estimate total solids. Therefore, for average situations, the formulas and lactometers considered here would be adequate for measuring total solids production of cows.

TABLE 2—Total solids calculated from the Quevenne and BDI lactometer readings and correlated with G (the single gravimetric total solids determination)

Formula	Average total solids*	Correlation with G†	
		Total	Intrafat level
	Percent	Quevenne lactometer‡	
1.....	14.89	0.95	0.75
2.....	14.54	0.96	0.76
3.....	14.68	0.96	0.76
4.....	14.71	0.96	0.76
5.....	14.52	0.96	0.76
G.....	14.75		
		BDI lactometer§	
6.....	15.16	0.95	0.72
7.....	15.22	0.95	0.72
8.....	15.13	0.95	0.72
G.....	14.93		

*Standard errors for these averages ranged from ±0.03 to ±0.05.
†Standard errors of estimate ranged from 0.31 to 0.40.
‡719 samples were tested with the Quevenne lactometer; fat averaged 5.3 percent and ranged from 1.5 to 8.5 percent.
§1,454 samples were tested with the BDI lactometers; fat averaged 5.5 percent and ranged from 1.5 to 8.5 percent.

Relations Between Fat, Solids-Not-Fat, and Total Solids in Milk from Two Jersey Herds

Prediction of total solids and solids-not-fat contents from the fat content in milk from Jersey herds was considered. The means and standard errors presented in Table 3 are similar to those reported by Specht et al. (1956). The correlations are similar to those presented by Harvey et al. (1954) who reported 0.92 for correlations between total solids and fat, and 0.37 between solids-not-fat and fat contents. They also reported a standard error of estimate of 0.46 for solids-not-fat and fat of individual Jersey milk, compared to 0.51 found in this study.

The regressions, *b* in Table 3, of solids-not-fat on fat for the two herds are similar but lower than those presented by Specht et al. (1956). The regression for the combined data in Table 3 was not significantly different from linear. Regression values for the different

TABLE 3—Relations between fat, solids-not-fat, and total solids in milk from two Jersey herds

Source	Number of		Means and standard errors			Correlations between F and		Standard error of estimate		SNF = a + bF	
	Cows	Samples	TS	SNF	F	TS	SNF	TS&F	SNF&F	*a*	*b*
			Percent	Percent	Percent						
Herd A.....	13	554	14.86 ± .07	9.49 ± .03	5.4 ± .05*	.92	.35	.39	.39	8.49	.185
B.....	24	513	15.07 ± .04	9.49 ± .02	5.6 ± .03†	.92	.32	.60	.60	8.50	.178
Combined data.	37	1,067	14.96 ± .04	9.49 ± .02	5.5 ± .03	.92	.34	.51	.51	8.49	.182

*Fat in Herd A samples ranged from 1.5 to 8.5 percent.
†Fat in Herd B samples ranged from 3.6 to 8.4 percent.

fat percent levels in the two herds varied considerably. Richardson and Folger (1950) reported such variations previously.

The constants in the prediction equation presented in Table 3 differ somewhat from many reported in the literature, the *a* values being higher and the *b* values lower. However, Harvey et al. (1954) reported similar values, *a* of 8.66 and *b* of 0.13, for individual Jersey milk samples.

Since total solids is composed of fat and solids-not-fat, the regression of total solids on fat is 1.0 plus the regression of solids-not-fat on fat. Therefore, the regressions of total solids on fat are 1.185, 1.178, and 1.182 for the three groups. The *a* values remain unchanged, except for rounding errors.

SUMMARY

Milk from individual cows was tested for total solids by lactometer and gravimetric methods.

Correlations greater than 0.9 were obtained between duplicate Mojonnier determinations on 974 milk samples, indicating that a single Mojonnier determination accurately determined total solids content.

Quevenne and BDI lactometer readings were applied to eight formulas for estimating total solids. Average total solids content calculated by TS=1.2 F+0.25 L+0.14 and TS=1.2F+0.25 L+0.173 for the Quevenne lactometer were not significantly different from the Mojonnier values. Correlations between total solids calculated by the formulas and by the Mojonnier method were over 0.9 when fat levels were ignored and about 0.7 when computed on an intrafat level basis.

Equations for predicting total solids and solids-not-fat contents from fat in Jersey milk were TS=8.49+1.182 F and SNF=8.49+.182 F, respectively.

LITERATURE CITED

Babcock, S. M. (1892). The estimation of total solids in milk from the percent of fat and the specific gravity of the milk. Wisc. Agr. Expt. Sta. Ann. Report 8: 292-307.

Harvey, W. R.; H. C. Hansen and J. C. Boyd (1954). Interrelations among lactometer readings, Westphal balance readings, formal titration test, Hart casein test, percent protein, casein, solids-not-fat, and butterfat of milk from individual cows. Proc. 35th Ann. Meet., Western Div., Am. Dairy Sci. Assoc.

Hermann, L. F. (1954). Indirect estimates of the solids-not-fat content of milk. U. S. Dept. Agr., Agr. Marketing Service, Marketing Research Division. Mimeo. 44 pp.

Hermann, L. F.; Elsie D. Anderson and F. A. Bele (1954). Estimating the solids-not-fat content of milk. U. S. Dept. Agr., Agr. Marketing Service Research Report 65. 13 pp.

Overman, O. R.; F. A. Davidson and F. P. Sanmann (1925). Relation of solids in milk to fat and specific gravity of the milk. Ill. Agr. Expt. Sta. Bul. 263.

Richardson, G. A., and A. H. Folger (1950). Compositional quality of milk. I: The relationship of the solids-not-fat and fat percentages. Jour. Dairy Sci. 33: 135-146.

Richmond, H. D.; G. D. Elsdon and G. H. Walker (1942). *Richmond's Dairy Chemistry.* 4th Ed. Charles Griffin, Ltd. London. 605 pp.

Specht, L. W.; J. R. Brunner, D. E. Madden and N. P. Ralston (1956). The influence of several factors on the protein and solids-not-fat content in the milk of Jersey cows. Jour. Dairy Sci. 39: 1337-1341.

Watson, P. D. (1956). A lactometer method for determining the solids in milk. U. S. Dept. Agr. ARS-73-10. 7 pp.

Whittier, E. O. (1954). Determination of milk solids. Proc. 23rd Ann. Inst. Dairying. State College of Washington, Pullman. pp. 99-103.

MICHIGAN BROILER TEST NO. 4

FALL 1956

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PURPOSE OF TEST

This was a descriptive test of varieties, strains, and strain crosses under environment and management conditions at the W. K. Kellogg Farm, Hickory Corners, Michigan.

The test was conducted on the ground floor of the two-story brooder house on the W. K. Kellogg Farm. Birds were entered on September 18, 1956. One hundred and four chicks (52 pullets and 52 cockerels) were required for an entry (Table 1). Each entry was placed in a pen of equal floor space (about 1 square foot per bird) which had been drawn by lot. Each chick was wing-banded for identification in order that a sample for the slaughtering data could be drawn.

If not debeaked when sent in, chicks were debeaked; they were then confined to a small area by a tight, solid corral for 2 days. Heat was supplied by heat lamps. Ceiling lights were used to prevent bunching.

Chicks were fed from a small feeder placed on paper. The paper was removed the second day. Large feeders were substituted for smaller feeders as the chicks grew. All feeders were the same type for each pen. Small fountains were used at first until the chicks were large enough to use automatic waterers. Sugarcane and straw were used for litter.

DISEASE CONTROL

A coccidiostat (NFZ) in the feed was used at recommended levels. At 10 days, the chicks were vaccinated by the water method against bronchitis. They were vaccinated at 4 weeks by the water method against Newcastle disease.

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TABLE 1—Entrants and breeding groups

Entry No.	Breeder	Male	Female
62	Cobb's Hatchery, Concord, Mass.	White Rock	White Rock
63	DeWitt's Hatchery, Zeeland, Mich.	Experimental	
61	Gulliver's Hatchery, Eaton Rapids, Mich.	Holtzapple Cross No. 5	Holtzapple White Nick
57	Holtzapple White Rock Farm, Elida, Ohio	Vantress White	Holtzapple White Rock
65	Holtzapple White Rock Farm	Holtzapple No. 5	Holtzapple White Rock
55	Klager Hatchery, Bridgewater, Mich.	Vantress	Arbor Acres
60	Klager Hatchery	Silver Broad	Holtzapple White Rock
54	Lambright Hatchery, LaGrange, Ind.	Experimental No. 1	
59	Lambright Hatchery	Experimental No. 2	
64	Lambright Hatchery	White Meateor	Arbor Acres
58	Neuhauser Hatcheries Coldwater, Mich.	Vantress	Arbor Acres
56	Weaver's Hatchery Wakarusa, Ind.	Vantress	Arbor Acres

WEIGHING AND SCORING

At 4 and 8 weeks, each entry was group-weighed, and the following information was obtained for the benefit of the breeder or hatchery: Average live weight, feed consumed, and number in each pen (Table 2).

At 10 weeks of age, the birds were individually weighed, checked for sex, and a random sample of 10 of each sex was taken for slaughtering (Table 3).

The samples were mixed in pens where they remained overnight. They were loaded the next morning—20 in a crate—and transported to the Hamilton Farm Bureau, Hamilton, Michigan. There, live weights were taken as they were hung on the dressing line. The eviscerated weights were recorded (Tables 4 and 5). The birds were scored following evisceration.

*TABLE 2—Feed conversion and mortality—10 weeks**

Entry No.	Mortality	Pounds of chicken per 100 lb. feed	Feed per lb. of chicken	Number	
				Males	Females
	(percent)	(lb.)	(lb.)		
62	4.80	37.76	2.65	47	52
63	1.94	38.40	2.60	44	57
61	4.90	36.87	2.71	45	52
57	.96	38.67	2.59	55	48
65	2.88	38.17	2.62	49	52
55	1.92	38.05	2.63	44	58
60	.96	36.28	2.76	33	70
54	2.88	39.27	2.55	52	49
59	.96	36.61	2.73	55	48
64	1.92	39.16	2.55	52	50
58	6.73	37.22	2.69	49	48
56	.96	39.46	2.53	54	49
Average...	2.57	38.02	2.63	..	..

*The feed for this fourth test was manufactured by the Valley City Milling Company of Portland, Michigan. This feed company had been selected by lot from the four feed mills operating in Michigan who indicated that they could supply a starter in crumble form.

TABLE 3—Live weight and variability of each sex—10 weeks—entire group

Entry No.	Males		Females	
	Average weight	Variability*	Average weight	Variability*
	(lb.)		(lb.)	
62	4.6	8.41	3.6	10.03
63	4.3	7.72	3.4	6.59
61	4.0	9.35	3.1	9.13
57	4.5	10.1	3.4	10.8
65	4.1	7.71	3.1	11.16
55	3.9	9.2	3.1	13.8
60	3.5	9.03	2.6	13.31
54	3.8	14.0	2.9	16.89
59	3.7	9.7	2.9	8.8
64	4.2	8.3	3.3	8.2
58	4.4	9.8	3.5	7.1
56	4.4	9.7	3.5	8.6
Average..	4.14	.....	3.19	.....

*Expressed as coefficient of variation. A low numerical value of the coefficient shows greater uniformity.

TABLE 4—Live and eviscerated weights of samples and carcass yields—10 weeks

Entry No.	Average weights				Carcass yields	
	Live		Drawn		Male	Female
	Male	Female	Male	Female		
	(lb.)	(lb.)	(lb.)	(lb.)	(Percent of live weight)	
62	4.5	3.5	3.45	2.6	70.2	75.5
63	4.2	3.35	3.18	2.6	75.2	77.6
61	4.02	3.15	2.94	2.35	73.1	74.6
57	4.38	3.19	3.36	2.43	76.7	76.2
65	4.31	3.28	3.18	2.52	73.8	76.8
55	3.98	3.02	2.97	2.36	74.6	78.1
60	3.51	2.69	2.69	2.2	76.6	81.8
54	3.64	2.97	2.84	2.35	78.0	79.1
59	3.67	2.99	2.84	2.39	77.4	79.9
64	4.0	3.4	3.13	2.63	78.3	77.4
58	4.13	3.34	3.18	2.59	77.0	77.5
56	4.32	3.16	3.38	2.56	78.2	81.0
Average.	4.06	3.17	3.09	2.46	75.8	77.95

*TABLE 5—Dressed score of samples—10 weeks**

Entry No.	Carcass grade†										
	Fleshing		Feathering		Fat		Conformation		Defects‡		Percent Grade "A"
	M	F	M	F	M	F	M	F	M	F	
62	1.3	1.7	1.0	1.0	1.0	1.14	1.1	1.3	1.1	1.3	35
63	1.3	1.6	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.0	65
61	1.6	1.8	1.0	1.0	1.3	1.2	1.3	1.1	1.1	1.1	40
57	1.1	2.0	1.1	1.0	1.1	1.3	1.3	1.2	1.2	1.0	75
65	1.6	1.7	1.1	1.1	1.0	1.1	1.3	1.2	1.2	1.2	40
55	1.2	1.8	1.0	1.0	1.1	1.4	1.4	1.3	1.2	1.1	90
60	1.7	2.4	1.1	1.2	1.3	1.9	1.3	1.7	1.1	1.2	50
54	1.3	1.6	1.0	1.1	1.5	1.4	1.4	1.8	1.2	1.2	65
59	1.4	1.6	1.0	1.0	1.2	1.1	1.1	1.2	1.0	1.1	85
64	1.4	1.7	1.0	1.0	1.2	1.2	1.3	1.3	1.1	1.1	65
58	1.2	1.5	1.0	1.1	1.3	1.4	1.4	1.2	1.5	1.2	65
56	1.3	1.8	1.1	1.0	1.1	1.1	1.1	1.2	1.4	1.3	65
Av....	1.36	1.76	1.03	1.04	1.17	1.27	1.27	1.31	1.2	1.15	..

*The authors express appreciation to Dr. L. E. Dawson, associate professor of poultry; and Hans Haugard, district marketing agent, for scoring and grading of eviscerated carcasses.

†Dressed score: 1, 2, 3, 4, 5. Based on Federal Standards of Quality; average score shown.

‡Defects: Includes breast blisters, crooked and dented breast bones, crooked backs, etc.

FEED

The chicks were fed a commercial broiler-starter until they were 8 weeks old. A broiler-finisher was used for the balance of the test. The guaranteed analysis of the starter was crude protein, minimum 20.0 percent; crude fat, minimum 2.0 percent; and crude fiber, maximum 4.0 percent. The finisher was guaranteed to contain 18 percent protein, 2.5 percent fat, and not over 4.5 percent fiber.

The feed for this fourth test was manufactured by the Valley City Milling Company of Portland, Michigan. This feed company was selected by lot from the four feed mills operating in Michigan who indicated that they could supply a starter in crumble form.

LIMITATIONS

Results from such samples should not be interpreted competitively by entrants.

Relatively little reliance should be placed on information from only one test. Repeated testing will be required to reliably evaluate real performance of strains and strain crosses. It is hoped this attitude will be expressed by the entrants in using these data for other than their own information. A winner cannot be picked because of the problem of fairly evaluating the various characteristics which were observed.

A PROGRESS REPORT OF THE EFFECT OF N-1-NAPHTYL PHTALAMIC ACID AND 2,4-DICHLORO-PHENOXYETHYL SULFATE ON 11 SPECIES OF GROUND COVER PLANTS

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IN THE FIRST 2 or 3 years after planting, there is a serious weed problem in ground cover plantings. Cover plants are usually planted close together and in irregular patterns; therefore, hand or mechanical weeding operations are difficult.

The use of herbicides would help solve the weeding problem. Accordingly, two known herbicides, N-1-naphtyl phtalamic acid (NP) (Alanap) and sodium 2,4-dichloro-phenoxyethyl sulfate (SES) (Crag-1), were used to determine herbicidal tolerance of several species of plants used as ground cover.[1,2]

MATERIALS AND METHODS

The species used in these tests were: *Ajuga reptans, Euonymus fortunei carrieri, E. fortunei vegetus, E. fortunei radicans, Lonicera japonica halliana, Hedra helix, H. helix baltica, H. helix bulgaria, H. helix colchica, Pachysandra terminalis and Vinca minor alba.*

Ten rooted, uniform plants of each species were transplanted into 10-inch clay pots. These pots were grouped so that each chemical treatment was replicated twice. The plants were grown in the greenhouse for the entire experiment.

One month later, the plants were thoroughly sprayed with a small handsprayer. In this way, the soil surface was also moistened, giving

[1]King, Lawrence J.; J. A. Lambrech and Thomas P. Finn (1950). Properties of sodium 2,4-dichlorophenoxyethyl sulfate. Contrib. Boyce Thompson Inst. 16(4): 191-208.

[2]Mahlstede, J. P. (1954). Chemical weed control in established nursery stock. Eleventh annual research report, North Central Weed Control Conf. pp. 121-122.

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the effect of pre-emergence weed control as well as foliar effects. Two months after the first application, the same plants were again treated in a similar manner. Before the second treatment was made, however, the shoot-growth was pruned to 15 inches from the base of the plants.

The chemicals were used at the following rates: NP at 3,000 and 6,000 p.p.m. (parts per million), and SES at 2,000 and 4,000 p.p.m. Based on the area sprayed and volume used, these rates represent about 3 and 6 pounds of NP and 2 and 4 pounds of SES per acre.

Plant response was rated on a scale from zero to 10, with 10 indicating normal plants compared to untreated plants, and zero showing dead plants. Plants rated anywhere in between these extremes showed some type of abnormality, such as: stunted or reduced shoot growth, deformed and off-color leaves, and excess root formation along stems of plants. To further evaluate plant response to NP and SES, tops and roots of the plants were weighed separately and compared to untreated plants.

RESULTS

Most of the ground cover species treated with NP or SES at two concentrations survived and grew. However, some of them were noticeably affected, as shown by the rating scale (Table 1).

Ajuga reptans was the only species that showed any injury from the SES treatment. All plants of this species died after the second application of 4,000 p.p.m. of SES. The other 10 species apparently were not affected by SES as far as top growth of the plant was concerned.

Euonymus fortunei radicans, E. fortunei vegetus, Lonicera japonica halliana and Vinca minor alba apparently were tolerant of two applications of NP at 3,000 and 6,000 p.p.m. since these species compared favorably in growth to untreated plants. Plants of *Pachysandra terminalis* exhibited some stunting and yellowing of the foliage, and those of *E. fortunei carrieri* showed a noticable reduction in shoot growth. All the plants of the *Ajuga reptans* were stunted and the leaves were dark green, cupped and leathery (Fig. 1).

The ivy species, *Hedra helix, H. helix baltica, H. helix bulgaria* and *H. colchica,* treated with NP produced twisted vine growth with numerous fasciated roots along the stem (Fig. 2). In general, growth was not reduced as much at 3,000 p.p.m. of NP as at 6,000 p.p.m.

TABLE 1—The effect of two applications of NP and SES on several ground cover species under greenhouse conditions

Ground cover species	Ratings of plants after first and second application							
	First rating*				Second rating*			
	NP (Alanap)		SES (Crag-1)		NP (Alanap)		SES (Crag-1)	
	3,000 p.p.m.	6,000 p.p.m.	2,000 p.p.m.	4,000 p.p.m.	3,000 p.p.m.	6,000 p.p.m.	2,000 p.p.m.	4,000 p.p.m.
Ajuga reptans	6	4	7	3	5	4	9	0
Euonymus fortunei carrieri	8	8	10	10	8	7	10	10
Euonymus fortunei vegetus	10	10	10	10	10	10	10	10
Euonymus fortunei radicans	10	10	10	10	10	10	10	10
Lonicera japonica halliana	10	10	10	10	10	10	10	10
Hedra helix	8+	8+	10	10	7+	6+	10	10
Hedra helix baltica	8+	6+	10	10	7+	6+	10	10
Hedra helix bulgaria	8+	7+	10	10	9+	8+	10	10
Hedra helix colchica	8+	6+	10	10	7+	6+	10	10
Pachysandra terminalis	8	8	10	10	8	7	10	10
Vinca minor alba	10	10	10	10	10	10	10	10

*0 = Dead plants. 10 = Normal plants.
+ Excessive root formation along stems.

Fig. 1. Plant of Ajuga reptans: (left) treated twice with NP at 4,000 p.p.m.; (center) untreated; (right) treated twice with SES at 2,000 p.p.m. Note cupped and leathery leaves of plant treated with NP.

At the end of the experiment, some of the plants showed signs of recovery at the lower concentration in the form of more normal shoot growth.

Since observations of top growth alone often does not reveal the total effects of a chemical on a plant, the roots were examined, weighed and recorded as the ratio of tops to roots of treated and untreated plants (Table 2). Any treated plant whose top-root ratio number exceeds that of the untreated check indicates a reduction of the root system; conversely, a lower number than the check indicates a larger root system.

Fig. 2. Plants of H. helix baltica: (left) treated twice with SES at 4,000 p.p.m.; (center) untreated; (right) treated twice with 6,000 p.p.m. NP. Note fasciation and clusters of roots along stem of NP-treated plants.

TABLE 2—Growth response (as expressed by top-root ratio) of ground cover plants to SES and NP, based on fresh weight of top and roots of plants

Ground cover species	Top-root ratio				
	(Crag-1) SES (p.p.m.)		Check	(Alanap) NP (p.p.m.)	
	2,000	4,000		3,000	6,000
Ajuga reptans	0.89	dead	0.81	0.88	1.81
Euonymus fortunei carrieri	0.77	0.92	0.71	1.11	1.40
Euonymus fortunei vegetus	1.98	2.28	1.65	1.99	2.71
Lonicera japonica halliana	0.27	0.35	0.21	0.24	0.31
Hedra helix	1.06	1.28	1.19	1.02	1.21
Hedra helix baltica	0.88	1.57	1.00	0.90	0.70
Hedra helix bulgaria	0.94	1.23	0.92	0.89	0.82
Hedra helix colchica	0.97	1.13	1.20	1.09	1.93
Pachysandra terminalis	0.79	1.17	0.73	0.63	0.87
Vinca minor alba	0.60	0.96	0.62	0.56	0.99

Some of the ivy plants, *Hedra helix, H. helix baltica* and *H. helix colchica,* treated twice with 2,000 p.p.m. of SES had a significantly lower top-root ratio, indicating that the roots were fully as vigorous as those of untreated plants. On the other hand, *Euonymus fortunei vegetus* showed some reduction of roots at the lower concentration of SES. At 4,000 p.p.m. of SES, all the plants uniformly indicated a more or less reduction of the root system.

Since, in most cases, the top growth of plants treated with both 3,000 and 6,000 p.p.m. NP was reduced to some extent, the top-root ratio did not give a true value of root development in relation to top growth compared to untreated plants.

On the other hand, plants that were apparently normal after two applications of NP (Table 1), show a trend similar to that described for SES; namely, that the lower concentration showed normal root development and the higher concentration some reduction in the root system (Table 2). There were no abnormal growth effects observed on any roots of NP-treated plants.

DISCUSSION

Many species of ground cover plants evidently are tolerant to some herbicides at rates that are detrimental to germinated weed seed and seedlings.

These studies with SES and NP indicate that excessive amounts of the chemical on or in the soil may inhibit and reduce root growth without any apparent reduction in top growth. This response is similar to restricted root formation following the use of SES as a soil spray shortly before rooting of strawberry runner plants.[3] With well-rooted plants, this may happen only where repeated applications of the herbicides are spaced so close together that some of the chemical accumulates.

The material NP apparently stimulated root growth on the stems of ivy plants to the extent that fasciation of the roots took place. This suggested that lower concentrations of this material may induce roots on stems or cuttings.

SUMMARY

1. Several species of ground cover plants were sprayed twice in the greenhouse with two concentrations of NP (Alanap) or SES (Crag-1) to determine : (1) their effects; and (2) the tolerance of these plants.

2. *Euonymus fortunei radicans, E. fortunei vegetus, Lonicera japonica halliana* and *Vinca minor alba* suffered no adverse effects when sprayed with 3,000 and 6,000 p.p.m. of NP (Alanap) at a 2-month interval. The other species also survived these treatments but showed malformed and stunted growth.

3. Plants of *Euonymus fortunei radicans, E. fortunei vegetus, Lonicera japonica halliana* and *Vinca minor alba* treated with SES (Crag-1) at 2,000 and 4,000 p.p.m. were normal after two applications. *Ajuga reptans* plants were killed by the higher concentrations.

4. The roots of the plants were reduced in proportion to tops when treated with either NP (Alanap) or SES (Crag-1), especially at the higher concentrations, as determined by the top-root ratio.

5. Most of the species studied showed a high degree of tolerance to SES (Crag-1) at herbicidal rates of 3 to 4 pounds per acre. Fewer species tolerated NP (Alanap) at 4 to 6 pounds per acre.

[3]Carlson, R. F., and J. E. Moulton (1951). Further testing of herbicides in strawberry plantings. Mich. Agr. Expt. Sta. Quart. Bul. 33: 262-268.

THE PRICE SUPPORT PROGRAM FOR DAIRY PRODUCTS IN RECENT YEARS

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ONE OF THE OBJECTIVES of the present Administration is to further price flexibility in agricultural price support programs. Through 1955, Congress limited the extent to which the flexible principle could be applied to the basic commodities.

Lower price supports have been put into effect for feed grains. However, few would maintain that this was a fair test in view of the production controls on basic commodities which have pushed the "diverted acres" into feed grains at the same time that price supports were reduced.

There is, however, one agricultural product on which the principle of flexible price supports has been more nearly applied. This is the price support program for dairy products. Most of our dairy products are produced and consumed domestically, so that changes in export demand should not determine the success or lack of success of the program.

In addition, dairy products are generally conceded to have a positive and reasonably high income elasticity among agricultural products, so that current domestic prosperity cannot be said to conflict with high consumption levels.

The flexible price support policy was applied to dairy products in 1954 and has remained in operation, more or less, to date. It seems appropriate at this time to evaluate (as far as possible from available data) the general impact of the flexible support programs on certain aspects of the dairy industry.

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THE SUPPORT PROGRAM IN RECENT YEARS

An amendment to the Price Stabilization Act of 1942 provided that prices to farmers for whole milk and butterfat were to be supported at not less than 90 percent of parity for the duration of the war and for 2 years following the cessation of hostilities. The Agricultural Act of 1948 specified that milk and butterfat were to be supported at 90 percent of parity, but the Agricultural Act of 1949 gave the Secretary of Agriculture discretion to vary the support levels between 75 and 90 percent of parity.

The near impossibility of storing fluid milk for a lengthy period means that the Commodity Credit Corporation (CCC) must limit its purchase program to milk products which are storable. Thus, CCC purchases butter, American cheese, and nonfat dry milk solids at a price calculated to return the support price to the farmers from whom the milk was purchased. It appears that the support program has maintained the actual price near the support price in recent years (Table 1).

Relatively little price support activity was required for dairy products in the early postwar years. The first purchases of consequence were made in 1949. The Commodity Credit Corporation

TABLE 1—Support levels and actual prices of manufacturing milk and butterfat: year beginning April 1, 1950-57

Marketing year beginning April 1	Manufacturing milk				Butterfat			
	Support level		Actual price		Support level		Actual price	
	Percentage of parity equivalent	Dollars per 100 pounds	Percentage of parity equivalent*	Dollars per 100 pounds	Percentage of parity	Cents per pound	Percentage of parity*	Cents per pound
1950-51....	79	3.07	87	3.40	86	60.0	92	64.2
1951-52....	87	3.60	96	3.97	90	67.6	99	74.1
1952-53....	90	3.85	93	4.00	90	69.2	93	71.6
1953-54....	90	3.74	83	3.46	90	67.3	88	65.6
1954-55....	75	3.15	75	3.15	75	56.2	76	57.1
1955-56....	80	3.15	81	3.19	76	56.2	77	56.9
1956-57....	84	3.25	86	3.31	81	58.6	81	58.8

*Actual prices during year as percentages of parity or parity equivalent just before beginning of marketing year. Actual prices for manufacturing milk during year as percentages of average parity equivalent during year were: 85, 93, 95, 84, 80, and 82, respectively. Comparable percentages for butterfat were: 89, 96, 95, 88, 76, and 78, respectively.

Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

TABLE 2—CCC purchases of dairy products under the Price Support Program: marketing years 1950-51 through 1955-56

(million pounds)

Marketing year beginning April 1	Total milk produced on farms during calendar year	Milk equivalent of U.S.D.A. purchases	Price support purchases		
			Butter	Cheese	Nonfat dry milk solids
1950.....	116,602	3,486	128†	109†	353†
1951.....	114,681	13	.2	.8	53
1952.....	114,671	3,619	143	75	210
1953.....	120,221	11,195	375‡	369‡	666
1954.....	122,094	5,744	211	153	523
1955.....	123,454	5,133	178	157	624
1956.....	125,700*	4,580	154	197	798

*Preliminary estimate.
†Includes purchases for 15-month period: January 1, 1950 through March 31, 1951.
‡Does not include 5 million pounds of butter and 87 million pounds of cheese purchased from dealers but resold after price supports were lowered.
Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

purchases of dairy products were significant in the 1950-51 marketing year; they declined substantially the following year.[1] In the 1952-53 marketing year, they again rose sharply to slightly above the 1950-51 level. In 1953-54 (the first year of the new administration), CCC purchases exceeded 11 billion pounds (milk equivalent) (Tables 2 and 3).

[1]The marketing year for dairy products begins April 1.

TABLE 3—Price support purchases of dairy products, and percentage purchases were of annual production: calendar years 1950-55

Year	Butter		Cheese		Nonfat dry milk solids		Milk equivalent	
	Mil. lb.	Percent of production	Mil. lb.	Percent of production	Mil. lb.	Percent of production	Mil. lb.	Percent of production
1950..	127.9	9.2	108.9	12.2	351.6	40.0	3,666	3.1
1951..	.2	.2	.8	*	53.5	7.6	13	*
1952..	16.1	1.3	2.8	.3	51.5	6.0	348	0.3
1953..	358.9	25.4	291.0	28.5	587.4	48.4	9,981	8.3
1954..	324.8	22.4	361.8	34.7	650.4	46.4	9,100	7.5
1955..	162.3	11.7	150.0	14.9	555.7	37.4	4,747	3.8
1956..	164.7	11.7	187.9	18.7	754.1	50.2	5,173	4.1

*Less than .1 of 1 percent.
Source: Calculated from U. S. Department of Agriculture statistics.

On February 15, 1954, the Secretary of Agriculture announced that the price support level for dairy products for the marketing year beginning April 1, 1954, would be lowered to 75 percent of parity. The support prices were maintained at the same dollars-and-cents level in the following year, but were raised slightly following the President's veto of the first farm bill in April 1956.

In announcing the lower price supports, Secretary Benson said: "The immediate problems of the dairy industry should be attacked through increased consumption of dairy products. The Department of Agriculture will continue and emphasize its programs to assist the dairy industry in its current campaign to increase sales of dairy products."[2]

In a March 29, 1954, news release, the Secretary elaborated further upon the objectives of the newly-announced program:[3]

". . . The Department is launching a nationwide educational program to increase culling of low-producing dairy cattle. Many experts believe that in recent months culling of dairy herds has been far below normal due to a combination of relatively low beef prices (which have strengthened considerably in recent months) and the incentive for excessive production through high rigid price supports.

"We expect to take further actions periodically during the year. Our overall dairy program falls into two parts. First, we are aiming at increasing consumption of dairy products, especially fluid milk. Second, we must dispose of government-held stocks of dairy products without demoralizing the commercial market.

"The two announcements today are only the first in a series of programs that we believe will stimulate consumption, increase profits to farmers and work toward relieving the government of the necessity of carrying burdensome stocks of perishable dairy products . . ."

Thus, the objectives of lower price supports for dairy products seem to have been stated quite explicitly as: (1) reduction of incentives to excess production; (2) encouragement of increased consumption of dairy products through lower prices; (3) reduction of government expenditures for dairy price support programs; and (4) increased income of milk producers. We will examine the 3-year period since the reduction in price supports to determine how nearly the objectives have been met.

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[2]U. S. Department of Agriculture (1954). News release 412-54 (mimeo). U. S. Dept. Agr., Washington.

[3]U. S. Department of Agriculture (1954). News release 826-54 (mimeo). U. S. Dept. Agr., Washington.

TRENDS IN MILK AND DAIRY PRODUCTS PRODUCTION

The number of milk cows on farms rose slowly from 1920 through 1939. There was a rapid increase during World War II (Table 4). After reaching a peak in 1945, the number declined until 1949 and has been relatively stable ever since.

Milk production per cow at the beginning of World War II was only slightly higher than in 1929, but there was a slight upward trend during World War II. Starting in 1945, milk production per cow has risen spectacularly, with nearly every year higher than the preceding year. The number of farms has declined and the use of milk on farms has declined, so increases in total milk production have been accompanied by increases in the proportion of milk marketed.

Since 1940, the proportion of milk sold as farm-churned butter has declined to zero, the percentage sold as farm-separated cream has declined from over 30 to about 12 percent, and the percentage retailed by farmers has declined. The proportion sold to dealers as whole milk has risen correspondingly.

TABLE 4—Milk cows on farms, production per cow, total milk production, and marketings: 1929 and 1940-56

Year	Milk cows on farms, Jan. 1	Production per cow	Total farm milk production	Milk marketed by farmers				
				Sold to plants and dealers		Retailed by farmers as milk and cream	As farm churned butter	Total
				As whole milk	As farm skimmed cream			
	Mils.	Lb.	Bil. lb.	%	%	%	%	%
1929...	22.4	4,579	99.0	33.7	34.2	6.9	2.8	77.6
1940...	24.9	4,622	111.9	43.1	30.1	5.6	1.3	80.1
1941...	25.5	4,738	112.4	45.2	29.5	5.2	1.2	81.1
1942...	26.3	4,736	118.5	49.8	26.2	5.0	1.0	82.0
1943...	27.1	4,598	110.8	51.0	25.5	4.9	.9	82.3
1944...	27.7	4,572	116.0	54.4	22.2	4.9	.9	82.4
1945...	27.8	4,787	114.9	57.5	19.9	4.7	.9	83.0
1946...	26.5	4,886	115.5	59.2	18.2	4.5	.9	82.8
1947...	25.8	5,007	117.8	60.4	17.9	4.2	.8	83.3
1948...	24.6	5,044	112.7	61.2	17.5	4.1	.8	83.6
1949...	23.9	5,272	115.2	63.1	17.2	3.7	.7	84.7
1950...	23.9	5,314	116.6	63.7	17.3	3.4	.6	85.0
1951...	23.6	5,333	114.7	64.9	16.2	3.3	...	84.4
1952...	23.1	5,374	114.7	67.4	14.7	3.1	...	85.2
1953...	23.5	5,542	120.2	70.3	13.6	2.7	...	86.6
1954...	23.9	5,657	122.1	72.0	13.1	2.4	...	87.5
1955...	23.5	5,815*	123.5	73.4	12.3	2.2	...	87.9
1956...	23.2	6,060*	125.7	†	†	†	†	†

*Preliminary.
†Not available.
Source: U. S. Department of Agriculture.

These figures suggest that, to date, the lowering of price supports has done little to reduce either of the factors determining milk production-numbers of milk cows and output per cow. The limited decline in numbers during the past 3 years does not suggest that cow numbers are being significantly reduced in response to lower price supports. Neither does it appear that the rate of increase in milk production per cow has slackened with lower price supports; in fact, preliminary figures for 1956 indicate that the rate still may be increasing.

This does not necessarily tell the entire story. Since the price of milk sold for fluid consumption depends upon several factors, it is less affected by a reduction in price supports than is the price of milk sold for manufacturing purposes or the price of butterfat. Thus, the prices of the latter products were reduced relative to the price of milk sold for fluid consumption and have remained lower during the past 3 years (Table 5).

Since the price of milk used for manufactured products was reduced relatively more by the reduction in price supports, the production trends in areas where a major portion of the milk is used for manufactured products should be compared with production trends in areas where most of the milk is used as fluid milk.

The eight leading producing states in which more than one-half of the milk produced was used for manufacturing in 1954 were compared with the same number of states in which manufacturing took less than one-fourth of the milk in 1954 (Table 6). In each of the

TABLE 5—Weighted average price paid by dealers for milk distributed in fluid form and average price received by farmers for manufacturing uses: 1950-56

Year	Fluid milk $ per cwt.	Manufacturing milk $ per cwt.	Ratio of fluid to manufacturing price
1950 ..	4.86	3.22	1.51
1951 ..	5.49	3.91	1.40
1952 ..	5.76	4.10	1.40
1953 ..	5.43	3.55	1.53
1954 ..	5.15	3.19	1.61
1955 ..	5.19	3.19	1.63
1956 ..	5.34*	3.28*	1.63

*Preliminary.
Source: Calculated from U. S. Department of Agriculture statistics.

TABLE 6—Changes in cow numbers, production per cow, and total milk production in selected states: 1953 to 1955

State	Percentage of milk used for manufactured products exclusive of ice cream	1955 as a percentage of 1953		
		Cows on farms	Production per cow	Total milk production
Wisconsin	72.6	102.2	101.6	103.8
Minnesota	77.7	101.2	101.8	102.9
Iowa	71.3	95.2	103.9	98.9
Missouri	53.1	96.9	107.5	104.2
Nebraska	72.9	97.7	104.3	101.9
North Dakota	60.9	99.7	104.2	104.0
South Dakota	53.0	96.2	103.9	99.9
Idaho	73.8	104.8	104.1	109.1
New York	22.6	102.8	102.3	105.2
Pennsylvania	9.5	102.5	104.6	107.3
Texas	7.0	90.1	105.0	94.6
Virginia	14.0	93.4	105.5	98.6
Massachusetts	4.6	95.9	105.1	100.9
Connecticut	1.7	100.9	102.7	103.7
New Jersey	3.3	99.3	102.9	102.3
Maryland	14.4	100.8	106.6	107.6

Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

states, cow numbers, production per cow, and total milk production were compared for 1953 and 1955.

In each of the two groups, six of the eight states increased milk production from 1953 to 1955. The rate of increase in the major fluid milk markets of the Northeast does not appear significantly greater than in the major manufacturing states of Wisconsin, Minnesota, and Missouri.

An examination of changes in cow numbers reveals that four of the states where the milk is sold primarily for fluid use and five of the states where the bulk of the milk is used for manufacturing purposes decreased cow numbers from 1953 to 1955. The two groups of states show similar percentage changes in milk production per cow, with somewhat smaller increases from 1953 to 1955 for those states where output was already higher.

As yet, then, there is no conclusive evidence that lower price supports for dairy products has significantly reduced the output of milk in those areas heavily dependent upon manufacturing outlets. This may be due to one of two reasons. First, even though the income of

dairy farmers was reduced by lower price supports, the decline in the prices of other agricultural products may have been such to maintain the relative income possibilities from dairying. Also, the salvage price for their investment in dairying may be so low that farmers are better off to continue in production rather than to sell out and change to another farming enterprise.

An examination of a number of ratios relating to the relative prices of dairy products and feed prices, and the relative price of dairy products and hogs and beef cattle, fails to show any sharp shift in these ratios that would account for either higher output per cow or maintenance of cow numbers. In any case, the supply of milk is apparently quite inelastic to reductions in price and, given the conditions of the past 3 years, lower price supports, within the range that has operated, do not seem to have appreciably affected output.

Even though total milk production does not appear to have been significantly reduced by the reduction in dairy price supports, it is possible that the utilization of the milk might be influenced by changes in the relative product prices. An examination of the trends in the production of the various manufactured products, however, does not indicate any sharp shift (Table 7).

After World War II, the production of creamery butter was considerably below its prewar level. The decline continued through 1952, followed by a significant increase in production in 1953. Butter production increased slightly again in 1954, the first year of lower price supports. Butter production declined about 4 percent in 1955, but preliminary estimates show a slight increase for 1956 with total production still well above 1952.

TABLE 7—Production of selected manufactured dairy products: averages, 1935-39 and 1945-49; annually, 1950-55

(million pounds)

	1935-39	1945-49	1950	1951	1952	1953	1954	1955	1956*
Butter, creamery	1,716	1,297	1,386	1,203	1,188	1,412	1,449	1,382	1,408
American cheese	513	880	893	873	850	1,021	1,042	1,002	1,007
Other cheese	161	261	299	288	320	323	341	361	387
Total cheese	673	1,141	1,192	1,161	1,170	1,344	1,383	1,363*	1,394
Nonfat dry milk solids	243	706	881	702	863	1,214	1,402	1,410*	1,480
Ice cream	1,279	2,741	2,633	2,718	2,846	2,904	2,866	3,024	3,130

*Preliminary.
Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

The production of American cheese has risen steadily over the years. After World War II, production appeared to have stabilized until 1953, when, like butter, it increased very sharply. It rose again slightly in 1954, declined about 4 percent in 1955, and remained about the same in 1956.

The production of nonfat dry milk solids climbed rapidly over the years through 1949. A sharply downward trend in 1950 and 1951 was replaced by an upward trend in 1952. The rate of increase declined in 1955, but preliminary statistics for 1956 indicate a resumption of the upward trend.

THE CONSUMPTION OF DAIRY PRODUCTS

Viewed in historical perspective, there appear to have been several divergent longer-term trends in the consumption of the different dairy products (Table 8).

TABLE 8—Per capita civilian consumption of selected dairy products and margarine: averages 1935-39 and 1945-49, annually 1951-55

(pounds)

	1935-39	1945-49	1951	1952	1953	1954	1955	1956*
Butter	16.8	10.5	9.4	8.5	8.4	8.7	8.9	8.8
American cheese	4.0	4.9	5.0	5.3	5.0	5.4	5.3	5.5
Ice cream	9.8	18.7	17.1	17.6	17.7	17.2	17.7	18.1
Nonfat dry milk solids	1.9	2.9	4.2	4.6	4.1	5.1	5.5	5.0
Fluid milk and cream	330	373	352	352	347	348	352	356
Total milk equivalent	791	750	705	691	682	691	698	699
Margarine	2.8	4.9	6.5	7.8	7.9	8.3	8.0	8.1

*Preliminary.
Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

The per capita consumption of butter had a slight downward trend before World War II, and this trend was intensified during the war. Under the pressure of heavy competition from margarine, the decline continued in the postwar period, with the per capita consumption of butter in 1953 at about one-half the 1935-39 average.

In the past 3 years, the per capita consumption of butter has remained about constant, and the 1956 consumption was still below the level for 1951. Perhaps more significantly, the per capita consumption of margarine declined for the first time in 1955 and remained at about the same level during 1956.

The per capita consumption of fluid milk and cream rose signifi-

cantly during the war and early postwar period; then, despite steadily increasing consumer incomes, it declined sharply toward prewar levels. The postwar low was reached in 1953 and 1954, followed by a 1 percent increase in both 1955 and 1956. The consumption of all dairy products on a milk-equivalent basis increased only slightly in each of the past 3 years and was still below the 1951 rate in 1956.

On the basis of these summary figures, it appears that the reduction in price supports has been successful in reversing the downward trend in dairy product consumption. However, the underlying statistics show a somewhat less optimistic picture (Table 9).

Upon examination, it appears that (with the possible exception of nonfat dry milk solids) the increased per capita consumption of supported products and fluid milk is accounted for by special government programs which either furnished the products at bargain prices or supplied the funds for increased purchases (Table 9). Butter consumption from commercial sources does appear to have gained from the 1953 low, but half the total gain was from special programs.

The fact that nearly all of the increase in per capita consumption of fluid milk from 1953 to 1956 resulted from increases in government programs seems significant, for fluid milk is the product for which market expansion seemed most possible with rising incomes and an increasing portion of the population in younger age groups.

An analysis based upon postwar cross-sectional data on food consumption shows an income elasticity of .17 for milk equivalent of dairy products.[4] Thus, it is to be expected that milk consumption should increase as real incomes rise. In addition, the American Dairy Association has been spending substantial sums in a national advertising and promotional campaign to increase milk consumption and is claiming that the program has proven successful.

In view of these factors which presumably should have increased the consumption of dairy products, it appears that claims regarding increased consumption due to lower consumer prices resulting from lowering price supports must indeed be modest.

There are at least two reasons why the expectations regarding potential increases in consumption from lowering price supports were probably overly optimistic. First, even though farm prices were lowered considerably, retail prices have been lowered less

[4]Faith, Clark, et. al., (1954). Food consumption of urban families in the United States. U. S. Dept. Agr., Agr. Information Bul. 132. p. 43.
This elasticity was computed using income per family of 3.5 persons and quantities from grouped data. Assuming that per capita income in constant dollars would roughly measure equivalent changes, the rise in per capita income from 1953 to 1955 should have increased milk consumption about 11 pounds.

TABLE 9—Dairy products—domestic civilian disappearance, commercial compared to other sources: 1947-56

Year	Per capita		
	Butter		
	From commercial sources	From CCC supplies or bought with government funds	Total‡
	pounds	pounds	pounds
1947	8.9	...	11.1
1948	7.9	...	9.9
1949	8.5	†	10.4
1950	8.5	.3	10.6
1951	7.9	...	9.4
1952	7.1	...	8.5
1953	6.8	.3	8.4
1954	7.1	.6	8.7
1955*	7.2	.7	8.9
1956*	7.1	.7	8.8
American Cheese			
1947	5.1	†	5.1
1948	5.0	0.1	5.1
1949	5.1	.1	5.3
1950	5.2	.2	5.4
1951	4.9	.1	5.0
1952	5.2	.1	5.3
1953	4.9	.1	5.0
1954	5.0	.4	5.4
1955*	4.7	.5	5.3
1956*	4.8	.6	5.5
Nonfat dry milk solids			
1947	2.9	†	2.9
1948	3.2	0.1	3.3
1949	3.1	.1	3.2
1950	3.4	.2	3.6
1951	4.1	.1	4.2
1952	4.5	.1	4.6
1953	4.0	.1	4.1
1954	4.8	.3	5.1
1955*	5.0	.5	5.5
1956*	4.4	.6	5.0

*Preliminary.
†Less than 0.05 pound.
‡For butter, includes farm production.

TABLE 9—Continued

Year	Per capita			
	Fluid milk and cream			
	From commercial sources	Regular School Lunch Program	Special School Milk Program	Total
	pounds	pounds	pounds	pounds
1947.....	365.8	3.1	...	368.9
1948.....	352.1	3.3	...	355.4
1949.....	347.8	3.8	...	351.6
1950.....	344.6	4.3	...	348.9
1951.....	347.5	4.6	...	352.1
1952.....	347.0	5.0	...	352.0
1953.....	342.0	5.2	...	347.2
1954.....	341.7	5.6	0.3	347.6
1955*....	343.7	5.7	3.0	352.4
1956*....	346.0	5.4	4.8	356.2

Year	Milk equivalent		
	From commercial sources	From CCC supplies or bought with government funds	Total
	pounds	pounds	pounds
1947.....	755	3	758
1948.....	710	4	714
1949.....	718	6	724
1950.....	718	13	731
1951.....	700	5	705
1952.....	685	6	691
1953.....	668	14	682
1954.....	670	21	691
1955*.....	670	28	698
1956*.....	668	31	699

*Preliminary.

Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

than proportionately: marketing margins have been maintained, and, in some cases, even increased. Moreover, most estimates of price elasticity for fluid milk are quite low, so that large increases in consumption would not be expected from relatively modest changes in retail prices.

Thus, as with production, evidence of the effects of lower price supports upon the consumption of dairy products is far from conclusive. It appears that the postwar decline in per capita consumption of dairy products has been ended or perhaps even reversed. Most of the increased consumption of the past 2 years can be attributed to government programs. Moreover, the increases might even be slightly below what would be expected from the general economic conditions during the period. However, we should remember that the postwar consumption decline took place during a period in which economic conditions were favorable for an increase in consumption.

DISPOSAL OF SURPLUS DAIRY PRODUCTS BY CCC

Although there have been heavy price support purchases in the past 4 years, it was announced on March 31, 1956, that the uncommitted CCC stocks of butter had disappeared and that supplies of cheese and nonfat dry milk solids were at new 3-year lows.

For butter, this marked a significant point in a successful surplus disposal campaign. Substantial success was also shown in the disposal of the other products. The cumulative uses of these surplus products during the 5 marketing years ending March 31, 1957 are shown in Table 10.

Over this period, slightly more than 60 percent of the surplus butter was disposed of through donations under Section 416 of the Agricultural Act of 1949; nearly two-thirds of these donations were made to foreign consumers. The next largest outlet was to Section 32 outlets, followed closely by transfers to the Army without charge. Commercial domestic sales of butter have been very minor, as have been commercial export sales.

For cheese, the major outlet has also been donations under Section 416, with about 60 percent of the donations going to foreign countries. Cheese is the only product for which commercial domestic sales have been significant in surplus disposal.

The disposals of nonfat dry milk solids have been dominated by

TABLE 10—Cumulative uses of surplus dairy products acquired under price support programs: April 1, 1952 through March 31, 1957

(million pounds)

	Butter	Cheddar cheese	Nonfat dry milk solids
Commercial domestic sales	23.9	136.7	6.0
Animal and mixed feed sales	...	.....	621.3
Section 32 outlets	141.8	67.1	48.7
Section 416 Donations:			
Domestic	244.4	246.0	259.5
Foreign*	391.1	366.9	1,148.0
Commercial export sales†	40.5	19.1	75.9
Commercial export—animal feed	.....	.....	114.0
Noncommercial export sales*	40.7	6.8	399.4
U. S. Army transfers	115.9	5.6	7.3
ICA transfers*	31.0	54.9	83.1
Other‡	14.5	.1	1.5
Total	1,043.8	903.2	2,764.7
Estimated uncommitted supplies: As of March 31, 1957	22.3	135.9	57.0

*Butter total includes the following quantities of butter programmed for conversion to butter oil for distribution through the three following outlets: 149,875,500 pounds for Section 416; 27,293,500 pounds for noncommercial export; and 2,940,000 pounds for ICA.

†Including 11,624,915 pounds of butter, 5,955,375 pounds of cheese, and 12,317,310 pounds of nonfat dry milk solids sold under Title I, P.L. 480 (foreign currency); 4,446,738 pounds of butter under International Cooperation Administration financing; and 1,000,000 pounds of nonfat dry milk moved under barter.

‡Other uses included butter salvage sale, cocoa butter extender sales, butter sales and donations to Veterans Administration, butter sold for industrial use abroad, donations of nonfat dry milk for research, donations to Foreign Agricultural Service for promotional exhibits abroad, butter sold for liquid milk recombining abroad, and milk resold to original vendor.

the large sales for animal and mixed feed use and by the large foreign donations. Noncommercial export sales have also been important in the disposal of the nonfat dry milk surplus.

The use of these outlets by time periods is also of some interest (Table 11). For each product, the domestic commercial sales rose during the 1954-55 marketing year but were down sharply during each of the next 2 years. Commercial export sales, on the other hand, have risen sharply during the last 2 years, probably largely as a result of Public Law 480 which authorizes sales of surplus agricultural products for foreign currency. The foreign donations of cheese and nonfat dry milk have expanded substantially each year; however, for butter, these foreign donations declined in 1956-57. Domestic donations of cheese and nonfat dry milk also expanded while those of butter declined in 1956-57.

TABLE 11—Utilization of surplus dairy products: April 1, 1953, through March 31, 1957
(million pounds)

	Butter				Cheddar cheese				Nonfat dry milk solids			
	1953-54	1954-55	1955-56	1956-57	1953-54	1954-55	1955-56	1956-57	1953-54	1954-55	1955-56	1956-57
Commercial domestic sales	3.7	19.9	.4	...	7.4	122.5	4.5	1.1	.1	4.4	.8	.9
Feed sales*	...	...	...	...	...	...	...	...	2.2	581.4	93.4	59.1
Donations:												
Domestic	68.8	112.4	118.7	68.5	24.3	85.2	86.1	117.3	9.5	73.7	85.8	130.3
Foreign	45.8	134.3	208.8‡	1.1	22.1	86.1	135.1	123.7	90.8	258.4	371.3	427.7
Export sales	...	2.1	24.4	9.4	...	.6	7.4	11.2	...	5.0	36.3	34.5
Noncommercial export sales	...	18.9	19.0‡	2.8	...	...	6.8	...	131.2	99.2	59.8	78.9
ICA transfers	...	9.1	3.6‡	18.3	.5	4.1	16.0	34.3	...	11.6	15.5	56.1
U. S. Army transfers	20.2	39.1	32.8	23.9	...	2.0	1.8	1.8	5.5	.1	.3	.1
Other†	.6	4.0	6.6	8.1	...	...	.0	.1	.1	...	1.1	1.1
Total	139.1	339.8	414.3	132.1	54.3	300.5	257.7	289.5	239.4	1,033.8	664.3	788.0
Uncommitted supplies: March 31	346.2	236.6	.0	22.3	472.3	328.6	228.2	135.9	595.7	86.3	46.4	57.0

*Includes 75 million pounds of dry milk sold for export for feed use during 1955-56 and 39.0 million pounds during 1956-57.

†Other includes butter salvage sale, cocoa butter sales, transfers to Veterans Administration, research donations, butter sold for industrial use abroad, promotional use abroad, butter sold for liquid milk recombining abroad, and milk resold to original vendor.

‡Foreign donation butter quantity, ICA transfers, and noncommercial export sales include 104.2 million pounds programmed for conversion to butter oil during the marketing year beginning April 1, 1955, and ending March 31, 1956.

The successful reduction in the surplus of dairy products has been accomplished at considerable expense to the Treasury. The cost figures that are available are difficult to interpret, particularly as to the cost of the various types of programs.

However, a recent compilation of the total cost to government and to the Commodity Credit Corporation shows a total cost for dairy products of $27.7 million in the fiscal year 1953, $257.8 million in fiscal 1954, $478.9 million in fiscal 1955, $490.9 million in fiscal 1956, and $180.4 million in the first 6 months of fiscal 1957.[5]

Thus, more than one-third of the $1.35 billion of the estimated cost of price support programs in fiscal 1955 was for dairy products. According to the same estimates, the cost of the program for butter alone from July 1949 through December 1956 was $832.6 million. This seems very high since the quantity of butter handled was 1,304 million pounds. Thus, it appears the loss on butter purchased for price support amounted to about 64 cents per pound.

These summary cost figures need a more detailed analysis than can be included in this paper. About all that can be concluded from the available cost data is that substantial progress can be made in surplus disposal if most of the product is given away or sold at a very low price for an inferior use. Even so, it is difficult to stay ahead of the game. It appears likely that the cost of dairy price support programs will continue high for a while at least.

THE INCOME OF DAIRY PRODUCERS

A complete evaluation of the income of dairy producers in recent years is difficult. Two statistical series published by the Department of Agriculture provide some estimates of the direction and magnitude of change. These are the estimated cash receipts from dairy products[6] and the series on farm costs and returns for commercial family-operated farms by type and location.[7]

Table 12 shows cash receipts from dairy products for recent years. They reached an alltime high in 1952. Even though price support levels were unchanged, cash receipts from dairy products were 4.4 percent lower in 1953 than for 1952. Cash receipts in 1954, the first year of reduced price supports, were down 5.8 percent from the previous year.

[5]U. S. Department of Agriculture (1957). The dairy situation. U. S. Dept. Agr. DS-259, pp. 15 and 18.
[6]Agricultural Marketing Service, U.S. Department of Agriculture, Washington.
[7]Agricultural Research Service, U.S. Department of Agriculture, Washington.

TABLE 12—Cash receipts by farmers from sale of dairy products: 1950-55

Year	Cash receipts (million dollars)
1950	3,719
1951	4,250
1952	4,567
1953	4,366
1954	4,114
1955	4,212*
1956	4,515*

*Preliminary.
Source: Agricultural Marketing Service, U. S. Department of Agriculture, Washington.

In 1955, cash receipts rose 2.4 percent above the previous year but were still below the 1953 levels. With higher production and slightly higher support levels, cash receipts in 1956 about equaled those in 1952. However, since production expenses have risen during this period, it appears likely that the net income of dairy producers has been reduced.

Some indication of the impact of the price declines on different areas can be seen by the changes in income on three types of commercial dairy farms (Table 13). In the Northeast, net income increased in 1954 and 1955 as greater output was marketed with approximately stable prices. In eastern Wisconsin, output did not increase enough to offset the year-to-year decline in prices, and net cash income in 1955 was more than one-fourth below that in 1953.

In western Wisconsin, where producers are highly dependent upon manufacturing outlets, a substantial increase in output in 1955 barely offset lower prices and maintained cash income at the 1954 level, about one-fourth below that of 1953.

Thus, while the overall cash receipts from dairy products have declined only moderately, the net income of producers in areas dependent upon manufacturing outlets have been reduced considerably by lower price supports. The possibility seems rather remote that expanding markets for these manufactured products will provide additional income for these groups of dairy producers and return their income to 1952 or 1953 levels.

TABLE 13—Costs, returns, prices, and production of three types of dairy farms: 1952-55

	1952	1953	1954	1955
Dairy farms: central Northeast				
Total cash receipts (dollars)	8,874	8,031	8,278	8,753
Total cash expenditures (dollars)	6,140	6,110	5,964	5,950
Net cash farm income (dollars)	2,734	1,921	2,314	2,803
Index of prices received for products sold (1947-49 = 100)	103	90	88	91
Index of net farm production (1947-49 = 100)	113	119	126	134
Index of production per unit of input	105	111	114	119
Dairy farms: eastern Wisconsin				
Total cash receipts (dollars)	8,104	7,141	6,643	6,405
Total cash expenditures (dollars)	5,025	4,673	4,720	4,646
Net cash farm income (dollars)	3,079	2,468	1,923	1,759
Index of prices received for products sold (1947-49 = 100)	107	95	87	83
Index of net farm production (1947-49 = 100)	104	109	113	111
Index of production per unit of input	103	106	106	106
Dairy farms: western Wisconsin				
Total cash receipts (dollars)	6,558	5,702	5,506	5,293
Total cash expenditures (dollars)	3,990	3,712	4,014	3,809
Net cash farm income (dollars)	2,568	1,990	1,493	1,484
Index of prices received for products sold (1947-49 = 100)	109	95	86	82
Index of net farm production (1947-49 = 100)	110	118	118	125
Index of production per unit of input	108	113	112	118

Source: U. S. Department of Agriculture (1956). Farm costs and returns, 1955. U. S. Dept. Agr. Information Bul. 158. 62 pp.

SUMMARY AND CONCLUSIONS

As yet there is no indication that lower supports have reduced milk production, and it appears that surplus production of certain dairy products is likely to continue to be a problem.

The consumption of dairy products appears to have increased since price supports were lowered. However, most of the increase is directly attributable to special programs to increase consumption or to the distribution of CCC surpluses at no cost to the receiver. Considering

the increased consumer income level, the gains in commercial sales of dairy products do not appear very large. The fact that the postwar downtrend has been ended may be significant.

In addition, it may be that CCC supplies and purchases from CCC funds have, in part, replaced other purchases. Thus, if these special programs were reduced, consumer purchases might expand and total consumption continue at present levels.

Price support purchases of dairy products have been lower in the 3 marketing years in which the lower supports have been in effect than in the last year of supports at 90 percent of parity. Part of this reduction, however, is attributable to the increased consumption of fluid milk which apparently has been due largely to special government programs. Even so, most people probably would agree that subsidizing the domestic consumption of fluid milk, especially by children, is preferable to the loan and storage and surplus disposal programs for manufactured products.

The dairy industry has received large government subsidies in recent years, and the extent of the subsidies has been more obvious than for storable products wherein large inventories were accumulated. The nature of the subsidies now appears to be shifting toward payments to stimulate increased consumption of fluid milk by school children. Based upon welfare criteria, this shift appears desirable if, as appears likely, we are to continue government aid to the dairy industry for some years.

CONSUMER PREFERENCES OF C-QUALITY FACTORS IN EGGS

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DO ALL C-QUALITY EGGS have the same consumer appeal? Are small bloodspots as serious as small meatspots, watery albumen, or abnormal looking yolks?

This study sought to answer these questions by determining how Detroit consumers would evaluate various low quality factors that cause eggs to fall into a Grade C classification.

This experiment was part of a consumer preference panel conducted by the home economics department of Wayne State University, Detroit, Michigan. The consumers were selected at random through the use of a telephone directory. They were then divided into categories according to their income: a sample of about 125 people, representing all of the normal income groups, was selected.[2]

METHODS AND PROCEDURE

Four different C-quality factors were evaluated for preference along with an A-quality control egg. The four factors that limited the egg to C-quality were: (1) a thin albumen, (2) an abnormal yolk color (yolks with brownish, mottled areas), (3) a small bloodspot (one-eighth inch in diameter), and (4) a small meatspot (one-eighth inch in diameter).

The eggs used to demonstrate the thin albumen and the abnormal yolks were artificially obtained by treatments with thioglycol and ammonia, respectively, before breaking to assure uniform quality characteristics. All of the eggs were of A-quality before the treat-

[1]The authors wish to express appreciation to Mrs. M. J. Bostick and Mrs. F. G. Sanderson of the home economics department, Wayne State University, for their help in planning the panel meetings.

[2]For further details regarding the selection of panel members, see: Larzelere, H. E., and R. D. Gibb (1956). Consumers' opinions of quality in pork chops. Mich. Agr. Expt. Sta. Quart. Bul. 39: 327-333.

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ments. There were no treatments on the eggs used to demonstrate a bloodspot, a meatspot, or an A-quality control.

To obtain a C-quality albumen, 1 dozen fresh Grade A Large eggs were held at room temperature for 8 hours. They were then placed in a desiccator containing 0.5 milliliter (ml.) of thioglycol as a desiccant; the eggs remained there at room temperature for 24 hours. Thioglycol, a liquid chemical that acts as a reducing agent, thins out the thick albumen and lowers the Haugh score[3] of an egg from about 80 or 90 to about 30. The yolk remained intact, with normal color and consistency.

The eggs used to demonstrate a C-quality yolk were exposed to ammonia for 8 hours. This caused a dark orange-colored yolk with a thickened viscosity. The albumen became somewhat thinner. This artificial coloring was slightly different than a natural abnormal yolk color.

The eggs were broken out on plates and displayed with other groups of eggs, meat, and produce. A preferential rating was given to all the components of each group. A total of 257 ratings were obtained: 125 in October, and 132 in November.

RESULTS AND DISCUSSION

Table 1 shows considerable variation in the desires and preferences of people in regard to quality factors of broken-out eggs. Although most of the consumers rated the control egg first, there were three people who thought it was the lowest quality egg; four people thought the egg with the abnormal yolk was the best egg, compared to 173 who rated it the lowest.

[3]Haugh score refers to an evaluation of egg albumen quality based on weight of the whole egg and height of thick albumen.

TABLE 1—C-quality egg preferences of Detroit consumers in October and November

Order of preference	Characteristics of broken-out egg				
	Control	Bloodspot	Meatspot	C-albumen	Abnormal yolk
	Number of preferences				
1	125	76	52	28	4
2	63	57	79	53	17
3	51	63	74	54	19
4	14	50	40	101	43
5	3	10	11	30	173

Table 2 shows the weighted preference scores, calculated with the highest scores showing the highest preference for that particular quality factor. A difference of 30 points in the preference score between any two factors was considered a significant difference.

As would be expected, the A-quality control received the highest weighted average score in both trials. The small bloodspots and meatspots were rated very close together, but they were considerably below the control. There was a sharp drop of 74.0 points to the fourth place C-albumen egg. The weighted score for the C-albumen egg was only 267.2 points, and the fifth-ranked (the abnormal yolk) rated only 165.7 points. Fig. 1 shows these relative differences.

In previous work by Larzelere and Dawson,[4] they found that small bloodspots and meatspots were nearly equal in preference rating. They also found that consumers showed a definite preference for medium-colored yolks over both light-colored and dark-colored yolks.

Eggs containing small bloodspots and meatspots less than one-eighth of an inch in size were preferred over thin, watery albumens or abnormal-colored yolks, and they were more readily accepted by consumers. The United States standards for quality of individual eggs place all four of these C-quality characteristics as equal in Grade C eggs.

However, since the average consumer does not consider them as equal, a revision of the standards of quality may be advisable in the future when more accurate devices are developed for detecting the interior quality of shell eggs. By the present candling technique, many

[4]Larzelere, H. E., and L. E. Dawson (1956). Evaluating consumer grades of eggs and poultry. Mich. State Univ. mimeo. (Unpublished)

*TABLE 2—Weighted preference scores for C-quality factors**

Order of preference	Characteristics of broken-out egg	Weighted preference score		
		October	November	Average
1	Control	389.7	393.4	391.5
2	Small bloodspot	330.9	351.4	341.2
3	Small meatspot	333.8	334.1	333.9
4	C-albumen	258.4	276.1	267.2
5	C-yolk	186.7	144.8	165.7

*For methods of calculating the weighted score, see: Larzelere, H. E., and R. D. Gibb (1956). Consumer opinions on pork chops. Mich. Agr. Expt. Sta. Quart. Bul. 39: 327-333.

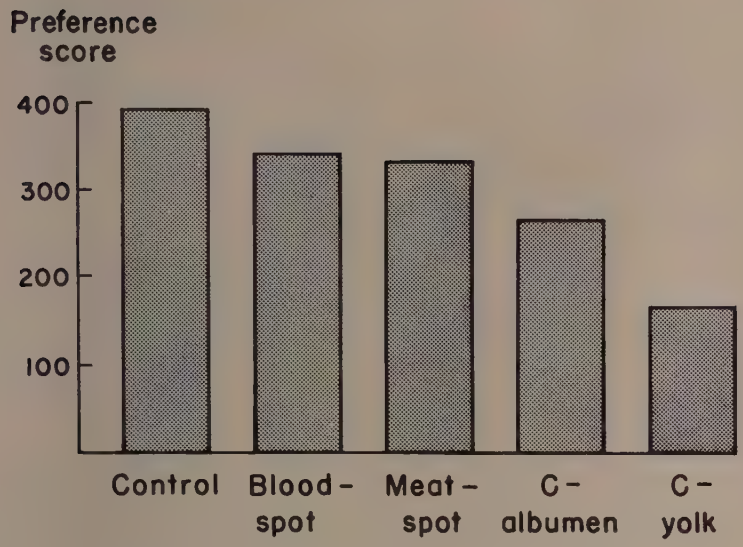

Fig. 1. Relative preferences of C-quality factors.

abnormal yolks are not easily detected; thus, eggs with this defect only are often placed no lower than Grade A.

This study indicates that, if and when a technique is developed for the detection of abnormal yolks in shell eggs, they should be placed at least as low as C quality, depending upon the degree of abnormal coloring. Any future revisions of the standards of egg quality should give more consideration to the preferences and demands of consumers.

SUMMARY

1. Most Detroit consumers recognize a good quality egg when it is compared to those of poorer quality.
2. The consistent preference for eggs with small bloodspots and meatspots over eggs with C-quality albumen, and for eggs with C-quality albumen over eggs with abnormal yolks, indicates that when more accurate grading devices are in general usage, the federal and state quality standards should conform more closely to these consumer preferences.
3. More comparison of the various C-quality characteristics—both artificial and normal—from a consumer preference standpoint is needed.

GROWTH OF ROSE, ALFALFA AND TOBACCO PLANTS AS AFFECTED BY DIFFERENT SOURCES OF IRON

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VARIOUS MEANS of supplying trace elements to plants when these elements are lacking in the soil or unavailable to plants have been devised. The simplest method is supplying the specific element as a salt to the soil.

This method is not always satisfactory since physico-chemical (Gisiger, 1950; and Page and Bodman, 1951) or biological (Norman, 1951) aspects of the soil may render the applied trace element unavailable to the plant. Further, the benefit obtained by supplying the trace element as a salt may be more or less temporary, since the conditions causing the original deficiency or unavailability may still exist. The plant may then require repeated applications of the trace element at regular intervals.

Also, the application of a mixture of all trace elements incorporated in a complete fertilizer in more than extremely minute quantities (i.e., in amounts more than will be found in the removed crop) or in trade mixtures of minor elements may be dangerous, since a specific soil may contain more than enough of one trace element while it is deficient in another.

Another method is foliar application of a dilution of a salt of the specific element. This treatment results in quick correction of a deficiency, but it must be repeated regularly.

Another method of supplying trace elements is the insertion of pellets or nails containing the deficient trace elements in the stem or trunk or under the bark of the plant. A disadvantage in this treatment is the deterioration of plant tissues in the immediate vicinity of the pellets.

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Newer materials supply trace elements as chelates or in frits. Chelates must be applied to the soil or as a spray on plant foliage in very small amounts, otherwise injury or even death of the plant may result. Hence, the effect of a chelate must be regarded as rather temporary. Disodium ferrous versenate is soluble and the chelated metal is readily available.

Frit is the partly-fused unvitrified material of which glass is made. Calcium and sodium silicates form the basis of agricultural frits. Trace elements can be introduced into the frit in specific amounts during the preparation of the frit. The use of frit was first suggested by Badger and Bray (1945) and later developed by Wynd (1950 and 1951). The material may be mixed into the soil, but it is relatively insoluble (Wynd, 1950) and is not designed for use as a foliage spray.

It is presumed that the trace element cations are suspended within the amorphous matrix of the frit and may be withdrawn from the surface by plant roots through contact absorption (Wynd, 1950 and 1951). The frit is little affected by the chemistry of the soil (Wynd and Bowden, 1951), but micro-organisms may obtain the trace element from the frit.

MATERIALS

Disodium ferrous versenate, a chelated iron containing 8 percent iron (calculated as metal), and a glassy frit designated as A-6285 — C XM 656 containing 7.5 percent ferric oxide (5.2 percent as metal) were selected as sources of iron.

Test plants selected were alfalfa, tobacco, and rooted cuttings of "Better Times" rose. The plants were grown in Oshtemo Sandy Loam in 8-inch pots. This soil was thought to be deficient or very low in available iron by the department of soil science, Michigan State University.

This "deficiency" was accentuated by the addition of lime. Each pot of soil received 5 grams of hydrated lime, 0.5 gram potassium nitrate, and 5 grams of 20 percent superphosphate. Four replications of pots of soil received 0, 5, 10, 15, 30, 60 and 90 grams, respectively, of frit or versene. Supplemental additions of KNO_3, $Ca(NO_3)_2$, or $KH_2\ PO_4$ were made at intervals as needed for growth of the plants.

Because of uncertainty of supply of distilled water, and because of a desire to maintain normal greenhouse cultural practices, it was decided to water plants with tapwater. While there is one part per million of iron in this water, there is also a large amount of calcium.

The excessive amount of calcium in the soil, resulting from the original application plus the irrigation, was felt to be sufficient to immobilize the iron in the soil.

PROCEDURE

Rose. Rose "Better Times" rooted cuttings planted in the soils containing chelated iron died. Plants exhibited toxic symptoms within a few days, increasing in severity with increasing amounts of disodium ferrous versenate. In treatments with the lowest amounts of disodium ferrous versenate, the first sign of injury in plant tissue was darkening of the leaf margins, followed by gradual yellowing and, finally, abscission of the leaves.

With increasing amounts of disodium ferrous versenate, the sequence of changes was more rapid. Stems of cuttings growing in soils with 30 or more grams of disodium ferrous versenate blackened within 10 days. Plants growing in pots containing 5 grams of disodium ferrous versenate were less severely affected; some axial buds started to grow, but the new leaves showed injury and the new growth soon died.

To determine if the toxicity of the disodium ferrous versenate was due to excess iron, several pots were arranged containing 1, 2, or 3 grams of the iron chelate and several pots containing 1, 2, or 3 grams of versenic acid (ethylenediamine tetra acetic acid).

The only plants that survived to productive maturity were those containing no more than 1 gram of chelate, either disodium ferrous versenate or versenic acid. All plants growing in soil containing frit grew to normal maturity, producing cut flowers for more than 2 years.

Alfalfa. Alfalfa seed was planted October 30, 1954, in 8-inch pots of Oshtemo Sandy Loam containing the various amounts of disodium ferrous versenate or frit. While this seed germinated well, the seedlings in soil containing the chelate died very soon after germination. The plants were then removed from all pots, and alfalfa was liberally reseeded November 22 in the same pots.

Many of the new seedlings died after germination, but transplants were made from control pots to establish six plants per pot. Hydrogen ion concentration of the soils in the pots, determined at intervals during the growth of the plants, was within a range of that indicated by pH readings between 7.0 and 8.0.

The alfalfa plants were grown to flowering stage, then cut off one-half inch above the crowns, dried, and weighed. Six cuttings were made between May 15, 1955, and August 8, 1956.

Tobacco. Uniform seedlings of "Common Havana" tobacco plants in the two- to three-leaf stage were transplanted October 20, 1954, into 8-inch pots containing Oshtemo Sandy Loam with the various amounts of chelate or frit. Three days later, the plants in soil containing disodium ferrous versenate were dead. After repeated replantings, plants were finally established in all pots. The tobacco plants were harvested February 22, as flower buds were appearing on plants in the frit treatments.

RESULTS

First plantings of seedlings of both tobacco and alfalfa and rooted cuttings of "Better Times" rose in soil containing disodium ferrous versenate died; it was only after repeated planting that plants of tobacco and alfalfa were established. The cotyledons of the alfalfa seedlings in the soil containing disodium ferrous versenate seemed to "burn off" to the stem as if they had been completely plasmolyzed. This exosmosis was apparently due to the physical properties of the disodium ferrous versenate and is not caused by the iron, ammonium or sodium components of the disodium ferrous versenate.

Tobacco plants in soil containing disodium ferrous versenate showed similar effects: an immediate and complete loss of turgidity of the tops of the seedlings. The roots were also completely dehydrated.

TABLE 1—Total dry weights of alfalfa grown in Oshtemo Sandy Loam containing various amounts of chelated iron or iron-containing frit

Treatment	Grams Fe supplied	Total grams dry weight	Treatment	Grams Fe supplied	Total grams dry weight
Control.....	.00	1,001.31			
5 gm. chelate..	.40	763.60	5 gm. frit..	.26	1,100.00
10 gm. chelate..	.80	759.60	10 gm. frit..	.52	896.70
15 gm. chelate..	1.20	784.50	15 gm. frit..	.78	838.80
30 gm. chelate..	2.40	816.50	30 gm. frit..	1.56	832.30
60 gm. chelate..	4.80	789.60	60 gm. frit..	3.12	959.90
90 gm. chelate..	7.20	680.80	90 gm. frit..	4.68	1,017.80

The total dry weights of alfalfa are recorded in Table 1. The average dry weights of the tobacco are recorded in Table 2. Analysis of variance of data in both tables was made. In both tables, the average dry weights of the plants grown in soil containing disodium ferrous versenate were significantly lower (at the 1 percent level) than the average of the dry weights of the plants grown in soil containing frit. The average dry weight of the plants grown in soil containing frit was significantly lower than the average dry weight of the plants grown as control.

TABLE 2—Average dry weights of tobacco plants grown in Oshtemo Sandy Loam containing various amounts of versene or iron-containing frit

Treatment	Grams Fe supplied	Average grams dry weight	Treatment	Grams Fe supplied	Average grams dry weight
Control.....	.00	55.30			
5 gm. chelate..	.40	41.40	5 gm. frit..	.26	58.80
10 gm. chelate..	.80	45.65	10 gm. frit..	.52	50.55
15 gm. chelate..	1.20	39.40	15 gm. frit..	.78	49.60
30 gm. chelate..	2.40	22.83	30 gm. frit..	1.56	46.50
60 gm. chelate..	4.80	6.20	60 gm. frit..	3.12	49.28
90 gm. chelate..	7.20	2.35	90 gm. frit..	4.68	60.53

The only treatments that resulted in greater dry weights of both alfalfa and tobacco than the control were those containing 5 grams and 90 grams of iron-containing frit (Tables 1 and 2). Wildon (1951) grew tobacco in a greenhouse soil containing various amounts of frits impregnated with iron, or iron and manganese. Similar variations were obtained for the dry weights of the same variety of tobacco grown in 6-inch pots with various amounts of frit containing iron added to the soil. The addition to the soil of frit containing iron and manganese resulted in dry weights progressively greater than the control with the increased amount of the frit in the soil.

The rose experiment was discontinued after the death of the plants in soil that contained disodium ferrous versenate, although the plants growing in soil that contained frit produced roses for a period of over 2 years.

DISCUSSION

It might be concluded that the iron applied to the soil either as frit or as disodium ferrous versenate was the cause of decreased growth. However, it should be pointed out that soils normally may contain up to 8 percent of iron compounds; occasionally, the percentage may be as high as 30 percent. The largest total amount of iron applied in any pot did not exceed 2.5 percent. The amount of iron extractable by roots from the frit during a given period is much less. Furthermore, Wynd and Wildon (1955) grew tomato plants in a substrate of iron frit flushed regularly with a nutrient solution without obtaining any evidence of toxicity from the iron.

It is possible, however, that the excess of calcium in the soil consequently absorbed by the plant roots partly immobilized the iron within the roots and, perhaps, within the leaves. Thus, a relatively small amount of absorbed iron may actually be available for normal chlorophyll formation or functioning. Increased amounts of available iron in the soil would then be required to provide an amount for full functioning of normal growth processes.

Biddulph (1951) has presented evidence that iron may be precipitated in the root and on root surfaces and that such immobilization of iron inhibits uptake of additional iron, phosphorus, and calcium.

The immobilization of iron within the roots may likewise interfere with movement of water and other nutrient elements upwards to the leaves and meristematic tissues, thus reducing the amount of growth without necessarily exhibiting visible symptoms of deficiency.

The reason all treatments with frit (except those at the 5-gram and 90-gram levels) resulted in less growth than the control is not clear. It is possible that treatments containing more than 90 grams of frit may have resulted in increased growth. Growth in soil containing different amounts of disodium ferrous versenate indicates a regular decrease of growth with increased amounts of disodium ferrous versenate.

It is possible that the entire versenate molecule is absorbed without change and, therefore, relatively small amounts become toxic. Or, the chelate molecule may exert a negative potential upon the root, causing a withdrawal of water and/or cations from the root to such an extent as to cause death of the plant or at least to decelerate uptake of moisture and/or nutrient cations.

CONCLUSION

The production of alfalfa and tobacco in soils treated with frit exceeded production in soils treated with equivalent amounts of chelate.

LITERATURE CITED

Badger, A. E., and R. H. Bray (1945). Soluble glass may offer fertilizer possibilities. Chem. and Metal Eng. 52(4): 112-113.

Biddulph, O. (1951). The translocation of minerals in plants. A paper, pp. 261-275, in E. Truog, ed. *Mineral Nutrition of Plants.* Univ. of Wis. Press, Madison. 469 pp.

Gisiger, Leo (1950). Deficiencies of minor elements caused by excesses. A paper, pp. 19-30 in *Trace Elements in Plant Physiology.* Chronica Botanica, Waltham, Mass. 141 pp.

Norman, A. G. (1951). Role of soil micro-organisms in nutrient availability. A paper, pp. 167-183, in E. Truog, ed. *Mineral Nutrition of Plants.* Univ. of Wis. Press, Madison. 469 pp.

Page, J. B. and G. B. Bodman (1951). The effect of soil physical properties on nutrient availability. A paper, pp. 133-166, in E. Truog, ed. *Mineral Nutrition of Plants.* Univ. of Wis. Press, Madison. 469 pp.

Wildon, C. E. (1951). A study of luxury absorption of iron and manganese in insoluble glassy frits by horticultural plants. Thesis for degree of Ph.D., Univ. of Mass., Amherst. 178 pp.

Wynd, F. L. (1950). The use of iron-containing frit as a new medium for hydroponic culture. Mich. Agr. Expt. Sta. Quart. Bul. 33: 52-53.

———————— (1951). Availability to wheat plants of iron in very insoluble glass frits. Lloydia 14: 1-33.

————————, and Roy A. Bowden (1951). Response of snapdragons to very insoluble iron-containing frit. Lloydia 14: 34-39.

————————, and C. E. Wildon (1955). The use of glass frit for the hydroponic culture of tomatoes. Lloydia 18: 109-128.

EVALUATION OF FOUR COMMON NESTING MATERIALS IN THE PRODUCTION OF CLEAN EGGS

By FLOYD W. HICKS[1]

One measure of successful poultry management practices is the percentage of the eggs that are clean when gathered. The percentage of dirty eggs produced represents a partial loss to the poultryman. He either receives a reduced price for his dirty eggs, or he must use extra labor to clean the outer surface. Soiled eggs also result in lower hatchability or poorer chicks; thus the hatcheryman is affected. Finally, the consumer is dissatisfied because of the lower quality eggs purchased.

Therefore, the management factor of finding and using a suitable nesting material which will tend to stay dry and clean and which will lower the percentage of stained or dirty eggs is important.

Several methods of cleaning dirty eggs are being used today. They result is an egg that is almost comparable to clean eggs in keeping qualities and outward appearance. However, these methods take time, skill and, often, special equipment. Good management practices would be much better.

At the Missouri Agricultural Experiment Station, Funk (1937) found that 99 percent of all eggs are clean when laid. Therefore, if certain management practices kept eggs in their original state of cleanliness, the problem of dirty eggs would be at least partially solved. One of these practices is the use of a suitable but inexpensive nesting material.

MATERIALS AND METHODS

Dawson (1955) studied the cleanliness of eggs produced by a commercial flock of Single Comb White Leghorns using nest materials

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of wood shavings, cane pulp, straw, chopped straw, chopped corncobs, excelsior pads, Drizone, and Chick-bed. He found that the greatest labor efficiency and lowest cost were obtained where well-constructed nests were supplied with Chick-bed, Drizone, cane pulp, shavings or ground corncobs.

Since this study was conducted at the Upper Peninsula Experiment Station at Chatham, Michigan, we investigated materials which are readily available and inexpensive in that area.[2] The materials used were shavings, chopped straw (2 to 2½ inches long), oats, and ground corncobs.

Shavings were compared to: (1) Oats in the same pen, (2) shavings vs. straw, (3) shavings vs. corncobs, (4) oats vs. straw, (5) oats vs. corncobs, and (6) straw vs. corncobs.

Beginning in July 1949, and continuing until June 1954, 183,883 eggs were collected and classified as to degrees of cleanliness by the station poultryman, George Leppamaki. No one egg was given more than one classification. The classifications used were: (1) clean, (2) slightly dirty, (3) medium dirty, (4) very dirty, and (5) broken and/or checked.

(1) **Clean** eggs were those that would pass cleanliness standards for Federal A quality.

(2) **Slightly soiled** eggs were those eggs with small areas slightly stained, less than one-fourth square inch of dirt on surface.

(3) **Medium dirty** eggs had one-fourth square inch of dirt or stain.

(4) **Very dirty** eggs had more than one-fourth square inch of dirt and stains.

(5) **Cracked and checked** eggs were eggs that had actual breaks in the shell, but the contents and shell membranes were not broken. **Leakers** were included in this classification.

To be salable, eggs in three classifications would have to be cleaned. Thus, the slightly dirty (2), medium dirty (3), and very dirty (4) classifications were grouped together to determine significance.

Before and during the study, the classifying of eggs was checked by J. M. Moore, Extension poultryman, Michigan State University. It was his opinion that perhaps the grading was too strict in the case of the slightly dirty eggs. Very small specks of dirt on the shells

[2]Ground corncobs were the exception. In the Upper Peninsula, they are inexpensive but not readily available.

would undoubtedly be graded as clean in a commercial flock. However, the original very strict grading was carried on for the complete period (1949-54).

In classifying the eggs as to degrees of dirtiness, no attempt was made to identify the type of soilage. It may have been interesting to note whether any of the nesting materials caused stains on contact with a warm, moist egg.

Confined New Hampshire pullets were used in this study. The same amount of space per bird (4 square feet) was allotted in each of six laying pens. No overcrowding effects in the form of abnormal mortality were noted, so it can be assumed that normal laying pen pressure could be expected in the nests. Some birds were setting on other birds in the same nest, but this occurred only early in the day.

Michigan-type community nests (2 feet by 4 feet), designed by Michigan State University poultry department members, were used in this experiment. Two nests of this type were used in each laying pen. Therefore, each nest would service less than 50 hens. The two openings of each community nest were covered with a cloth flap to darken the nest.

Every two months, the nesting material in each nest was rotated with the other nest in the pen. That is, the nest litter of each of the two nests within the same pen was reversed during the same day. The arbitrary time factor was the only one used in changing the materials. Nesting material was added to the nests when needed. Table 5 shows the amounts of each nesting material used in 1 year.

The floor litter was shavings, built up during the year to 5 inches. The floor litter was stirred often to keep it loose and dry. Lime was often added to maintain the litter in a dry condition and to reduce the tracking of dirt into the nests.

Additional heat was provided by woodburning, barrel-type stoves during the winter months, November through April. These stoves were surrounded by a layer of stone to prolong the heat. This heat aided the condition of the floor litter considerably.

Eggs were gathered in wire baskets. However, no attempt was made to separate the dirty and clean eggs in the basket. The soiled eggs were cleaned with a motor-driven, wheeltype sander.

Pits were covered with wire netting to keep the birds out of the droppings. Many eggs become soiled if they are left in the nests too long; they become broken and smear other eggs, or hens soil them by

walking on them. Therefore, the eggs were gathered three times a day: 10 a.m., 12 noon and 4:50 p.m.

The data cover the months of July through May of each fiscal year at Chatham. Funk (1937) found that hot, dry weather increased the percentage of clean eggs produced. Fig. 1 gives the monthly average temperatures and total precipitation during the 5-year period of this study.

The Chi-square test (Pearson, 1900) was used for the statistical analyses of the data. Statistical significance is indicated by the use of a single asterisk (*) for significance at the 5 percent level and a double asterisk (**) for significant differences at the 1 percent level. The "t" test (Snedecor, 1946) was used to substantiate the results, but only the Chi-square test is reported here.

EXPERIMENTAL RESULTS AND DISCUSSION

The hypothesis tested was: The numbers of clean eggs produced by laying hens on one type of nesting material are the same as the numbers of clean eggs produced by laying hens on another type of nesting material when both materials are in separate nests in the same laying pen.

The experimental results in Table 1 show in individual nesting material percentages that 94.15 percent clean eggs are produced on shavings; 91.89 percent on straw; 90.64 percent on oats; and 87.69 percent on ground corncobs. Table 1 shows the percentages of clean eggs produced each month out of the total number of unbroken eggs.

In making individual nesting material comparisons, the total numbers of unbroken eggs and the total numbers of clean eggs are considered. The question arises, then, as to whether or not the percentage differences in clean eggs produced as shown in Table 2 are significant when there are differences in numbers of eggs produced.

Shavings vs. corncobs.—When using the Chi-square method of analyses, a highly significant Chi-square value of 739.4713** was obtained (any figure over 6.635 would be highly significant). The experimental results show that shavings are superior to corncobs in producing clean eggs.

Shavings vs. straw.—The experimental results, as shown in Table 2, indicate that shavings are highly significant in their desirability over

TABLE 1—A 5-year summary of data grouped according to cleanliness

Month	Shavings			Straw			Oats			Corncobs		
	Total unbroken eggs†	No. clean eggs‡	Percent clean	Total unbroken eggs†	No. clean eggs‡	Percent clean	Total unbroken eggs†	No. clean eggs‡	Percent clean	Total unbroken eggs†	No. clean eggs‡	Percent clean
July	2,160	2,060	95.37	2,971	2,742	92.29	1,888	1,727	91.47	.....	.....	.....
August	4,434	4,273	96.37	7,765	7,327	94.36	4,640	4,389	94.59	989	792	80.08
September	4,229	4,060	96.00	7,737	7,311	94.49	3,695	3,512	95.05	655	585	89.31
October	4,334	4,120	95.06	8,994	8,404	93.44	4,258	4,040	94.88	993	852	85.80
November	6,584	6,132	93.13	9,161	8,333	90.96	5,236	4,803	91.73	1,529	1,339	87.57
December	6,958	6,536	93.94	6,824	6,305	92.39	4,533	4,108	90.62	1,812	1,592	87.86
January	6,387	5,910	92.53	6,676	6,103	91.42	4,066	3,703	91.07	1,853	1,685	90.93
February	5,466	5,166	94.51	6,674	6,099	91.38	3,645	3,379	92.70	1,961	1,733	88.37
March	5,710	5,386	94.33	6,310	5,726	90.74	3,547	3,300	93.04	2,345	2,086	88.96
April	4,767	4,477	93.92	4,911	4,338	88.33	3,199	2,895	90.50	2,089	1,830	87.60
May	2,414	2,196	90.97	3,262	2,818	86.39	1,795	1,627	90.64	1,241	1,069	86.14
Total	53,443	50,316	94.15	71,285	65,506	91.89	40,502	37,483	92.55	15,467	13,563	87.69

†"Total number of unbroken eggs" does not include broken and checked eggs.
‡"Number dirty eggs" are remaining groups classified together that needed to be processed before sale (slightly dirty, medium dirty and very dirty).

straw in producing clean eggs. However, the differences between shavings and corncobs are greater than differences between shavings and straw.

Shavings vs. oats.—The difference between these two nesting materials is only 1.60 percent; yet, when analyzed, the differences are highly significant at the 1 percent level. This means that there is less than one possibility in 100 that a difference this large could have occurred by chance alone. Therefore, the differences must have been due to treatment (the use of a certain nesting material).

Oats vs. corncobs.—The X^2 value of 328.9743** showed that the differences between these two nesting materials were highly significant in favor of the oats.

Oats vs. straw.—When there is a choice between these two nesting materials on the farm, the experimental results show that oats are superior to straw in producing clean eggs. The differences between these two treatments are closer than all of the other five comparisons, yet the difference was highly significant ($X^2 = 14.7895$**) in favor of oats.

TABLE 2—Comparisons of nesting materials in the production of clean eggs

Comparison	Treatment	Total number eggs	Total number clean	Percent clean	X^2	Difference in percentage of clean and dirty eggs	Superior nesting material in comparison
1.	shavings	53,443	50,316	94.15	739.4713**	highly significant	shavings
	vs.						
	corncobs	15,467	13,563	87.69			
2.	shavings	53,443	50,316	94.15	234.4056**	highly significant	shavings
	vs.						
	straw	71,285	65,506	91.89			
3.	shavings	53,443	50,316	94.15	96.8122**	highly significant	shavings
	vs.						
	oats	40,502	37,483	92.55			
4	oats	40,502	37,483	92.55	328.9743**	highly significant	oats
	vs.						
	corncobs	15,467	13,563	87.69			
5.	oats	40,502	37,483	92.55	14.7895**	highly significant	oats
	vs.						
	straw	71,285	65,506	91.89			
6.	straw	71,285	65,506	91.89	278.1667**	highly significant	straw
	vs.						
	corncobs	15,467	13,563	87.69			

**Highly significant at the 1 percent level, using Chi-square method of analysis.

TABLE 3—A 5-year summary of data grouped according to broken and checked eggs

Month	Shavings			Straw			Oats			Corncobs		
	Total number eggs	No. checks and broken	Percent checked and broken	Total number eggs	No. checks and broken	Percent checked and broken	Total number eggs	No. checks and broken	Percent checked and broken	Total number eggs	No. checks and broken	Percent checked and broken
July	2,194	34	1.55	3,028	57	1.88	1,909	21	1.10	...	...	...
August	4,500	66	1.47	7,907	142	1.80	4,715	75	1.59	1,009	20	1.98
September	4,309	80	1.86	7,855	118	1.50	3,756	61	1.62	663	8	1.21
October	4,382	48	1.10	9,130	136	1.49	4,320	62	1.44	1,004	11	1.10
November	6,653	69	1.04	9,293	132	1.42	5,299	63	1.19	1,554	25	1.61
December	7,041	83	1.18	6,948	124	1.78	4,584	51	1.11	1,834	22	1.20
January	6,489	102	1.57	6,820	144	2.11	4,132	66	1.60	1,868	15	.80
February	5,575	109	1.96	6,845	171	2.50	3,697	52	1.41	1,986	25	1.26
March	5,801	91	1.57	6,477	167	2.58	3,608	61	1.69	2,382	37	1.55
April	4,877	110	2.26	5,047	136	2.69	3,278	79	2.41	2,130	41	1.92
May	2,503	89	3.56	3,365	103	3.06	1,861	66	3.55	1,275	34	2.67
Total	54,324	881	1.62	7,215	1,430	1.97	41,159	657	1.60	15,705	238	1.52

Straw vs. corncobs.—In this comparison, straw was shown to be superior to corncobs, as the difference in percentage of dirty eggs (4.2 percent) was highly significant ($X^2 = 278.1667^{**}$).

All nesting materials received the same maintenance. Yet, there were highly significant differences between all nesting materials compared as to percentages of clean eggs produced. The nesting materials, therefore, when compared one against the other in the six pens, ranked as follows: (1) shavings, (2) oats, (3) straw, and (4) corncobs.

PRODUCTION OF BROKEN AND CHECKED EGGS

As a nesting material, shavings resulted in 1.62 percent broken and checked eggs; straw, 1.97 percent; oats, 1.60 percent; and corncobs, 1.52 percent (Table 3). It would appear that there was no significant difference between shavings and oats as a nest litter in regard to broken and checked eggs.

Table 3 shows a percentage difference between shavings and corncobs, and oats, and corncobs; however, when the sample size was analyzed statistically, there was no significant difference.

Table 4 shows that there was no significant difference between

TABLE 4—Comparisons of nesting materials in producing checked and broken eggs

Comparison	Treatment	Total number eggs	Total number checks and broken	Percent checks and broken	X^2	Difference in percentage of checks and broken eggs	Superior nesting material in comparison
1.	straw	72,715	1,430	1.97	20.6931**	highly significant	shavings
	vs.						
	shavings	54,324	881	1.62			
2.	shavings	54,324	881	1.62	0.8821	not significant	no difference
	vs.						
	corncobs	15,705	238	1.52			
3.	shavings	54,324	881	1.62	0.0971	not significant	no difference
	vs.						
	oats	41,159	657	1.60			
4.	straw	72,715	1,430	1.97	20.0218**	highly significant	oats
	vs.						
	oats	41,159	657	1.60			
5.	straw	72,715	1,430	1.97	14.2171**	highly significant	corncobs
	vs.						
	corncobs	15,705	238	1.52			
6.	oats	41,159	657	1.60	0.4807	not significant	no difference
	vs.						
	corncobs	15,705	238	1.52			

**Highly significant at the 1 percent level, using Chi-square method of analysis.

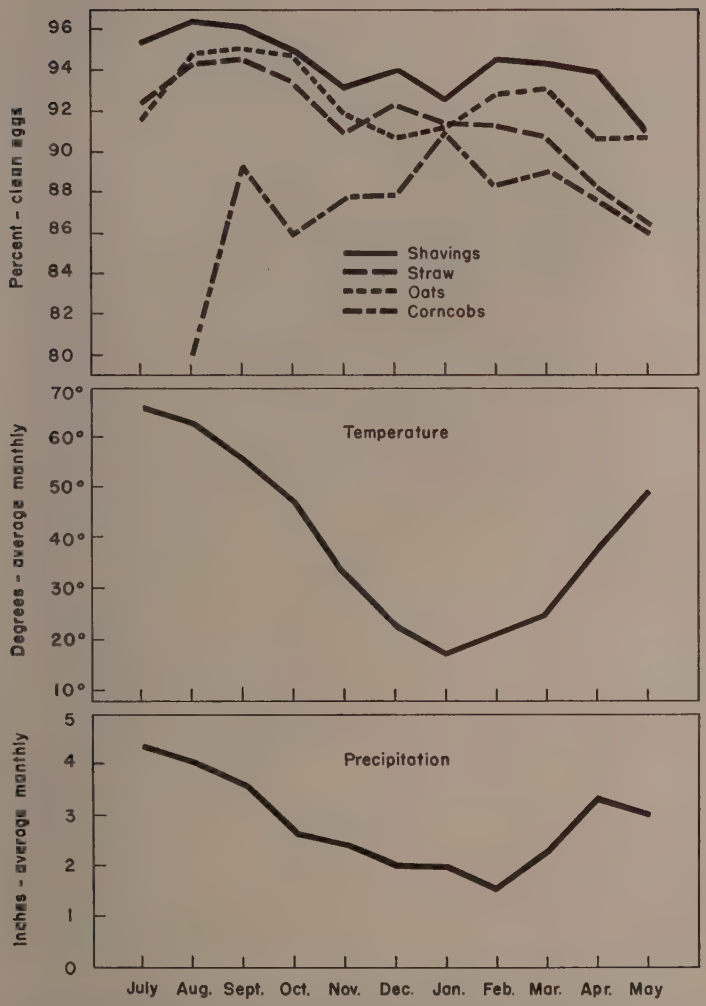

Fig. 1. Monthly trends in clean eggs related to temperature and precipitation, 1949-1954. (Four nesting materials used.)

three particular nesting materials—shavings, oats, and corncobs—in relation to broken and checked eggs. Straw, however, was inferior to all three of these materials in regard to broken and checked eggs.

CORRELATION WITH WEATHER CONDITIONS

Fig. 1 graphically plots average monthly temperature and the total monthly precipitation figures (including snow and rain) for the 5-year period of this experiment at the Upper Peninsula Experiment Station at Chatham, Michigan.

Fig. 1 also shows the 5-year average monthly percentages of clean eggs produced by the four nesting materials tested. No inside or outside humidity figures were available for a more detailed comparison.

The differences in the percentage of clean eggs of the various materials are shown graphically and have been analyzed. The performance trend of all four materials was downward as the season progressed from July through to May; this, in part, may be due to the deterioration of the nesting materials. When the laying season started (July-September), the nesting materials were new. Even though the precipitation was as high as in the spring months, the temperature was much higher and, therefore, the moisture-carrying capacity of the air was increased.

In the winter months of December, January, February, and March, the temperature was lower, but so was the total precipitation (snow). The percentage of clean eggs produced during this period remained quite constant. As the spring months progressed and the humidity increased, the percentage of dirty eggs increased.

In Fig. 1, note that the lines representing oats and straw intersect. The deflection came in August, November, and January. Otherwise, all of the materials kept their relative position above or below each other.

TABLE 5—Amounts and cost of nesting materials in 1 year

Nesting material	Average number of times nests were filled	Average amount per nest (lb.)	Cost per nests
Shavings	3.5	35.0	$0.35
Oats	9.0	311.5	7.79
Straw	3.5	21.5	0.215
Ground corncobs	1.5	63.5	0.57

AMOUNTS OF NESTING MATERIALS

The amount of nesting materials used and the number of times that the nests had to be filled indicate the labor involved to maintain the nests in a serviceable condition. Table 5 indicates that extra time was spent in maintaining a nest when oats were used as the litter. A smaller amount of labor was spent in maintaining ground corncobs as a nesting material; but, when egg cleanliness was considered, ground corncobs were inferior to the other three nesting materials.

COST OF NESTING MATERIALS

Nesting material costs differ in various areas of Michigan. At Chatham, the cost per load of 5 cubic yards of shavings came to $5.00 for labor and trucking. This would amount to 1¢ per pound or less. Using shavings, the total cost per nest, therefore, would be 35¢.

Straw plus the cost of chopping comes to about 1¢ per pound, or a total of 21.5¢ per nest.

Ground corncobs, figured at $18 per ton or 9¢ per pound, total 57¢ per nest.

Oats were the most costly litter to maintain. It cost $7.79 per year per nest to use oats as nest litter. The oats were eaten by the birds and became part of the diet.

Shavings and straw were the two most reasonably priced nesting materials.

SUMMARY

Four different nesting materials were compared over a period of 5 years for their relative value in the production of clean, unbroken, and unchecked eggs in the Upper Peninsula. New Hampshire pullets housed in six different laying pens were used in the study. Statistical analyses were made of all possible comparisons.

Cleanliness: Six comparisons were made: (1) shavings vs. oats, (2) shavings vs. straw, (3) shavings vs. ground corncobs, (4) oats vs. straw, (5) oats vs. ground corncobs, and (6) straw vs. ground corncobs. All differences were highly significant at the 1 percent level.

The order of desirability was: (1) shavings, (2) oats, (3) straw, and (4) ground corncobs. Each nesting material was highly significantly superior to the material ranked below.

Broken and checked eggs: Straw was found to be inferior to all of the other nesting materials in relation to broken and checked eggs. There were no significant differences between shavings, oats, and ground corncobs.

Weather conditions were correlated with the number of dirty eggs. As moisture conditions increased in the spring, the number of dirty eggs increased.

The numbers of times that the nests needed to be serviced are an important labor and litter cost factor. Oats needed to be replaced three times more often than did the other nesting materials.

All factors considered, shavings were found to be superior to the other three nest materials tested in the production of clean, unbroken, and unchecked eggs in Michigan's Upper Peninsula.

LITERATURE CITED

Dawson, L. E. (1955). Production of clean eggs. Mich. Agr. Expt. Sta. Quart. Bul. 37: 316-323.

Funk, E. M. (1937). Factors influencing the production of clean eggs. Mo. Agr. Expt. Sta. Quart. Bul. 384.

Pearson, K. (1900). On the criterion that a given system of deviations from the probable in the case of a correlation system of variables is such that it can be reasonably supposed to have risen from random sampling. The London, Edinburgh and Dublin Phil. Mag. and Jour. Sci. 5(50): 157-175.

Snedecor, George W. (1946). *Statistical Methods.* Iowa State College Press, Ames. 341 pp.

United States Weather Bureau (1949-54). Annual weather summary.

STORAGE OF ALFALFA SEED IN THE PRESENCE OF HERBICIDES

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NOW THAT MANY HERBICIDES are in general use on farms and in experiments, it is necessary to determine the conditions under which the common storage and transportation of seeds and herbicides is hazardous.

Common experience has shown that some of the more volatile substances can cause greater damage than the nonvolatile ones. Professor Boyd Churchill[1] was asked to select a group of herbicides that would represent the general range of volatility and other properties of the more commonly used preparations (see Tables 1 and 2).

EXPERIMENTAL PROCEDURE

The herbicide, at full commercial strength and absorbed in a piece of blotting paper, was placed in the bottom of a 250 cubic centimeter flask. Two lots of alfalfa seed were used. One was Vernal, low in hard seed; the other was a Michigan seed high in hard seed content.

About 25 grams of each alfalfa seed were placed in a cheesecloth bag and suspended in a flask which was then stoppered. Care was taken to prevent direct contact of seed and herbicide and to limit the effect to that of exposure to the concentrated vapors at room temperature. In spite of the precautions, very slight and temporary direct contact of the bag and the blotter did occur on a few occasions.

After exposure to the vapors for various lengths of time, the bags were removed, a sample of the seeds taken for germination, and the sacks returned to the flasks.

In the second part of the trial, fresh bags of seed were first exposed to a very damp atmosphere by placing watersoaked blotters in the flasks for 1 day. This exposure dampened the seeds con-

[1]Department of farm crops, Michigan State University.

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siderably. After exposure to the vapors of the herbicides, the seeds were germinated as before. After 13 days exposure, the residues were hung in the open air for 24 days to see if the volatile herbicides would be dissipated and their injury reduced.

EXPERIMENTAL RESULTS

Table 1 shows the germination of alfalfa seed after exposure to the fumes of the various herbicides. These seeds, taken directly from warehouse storage, were of ordinary dryness. Since there was considerable variation in "hard seed," the results are given as "probable live seed" which is the sum of germinating and hard seeds. Since the two lots of seed appeared to react identically, only the first data from the Michigan lot are included.

From results shown in Table 1, it appears that no damage was done by exposing dry alfalfa seeds for 13 days to the vapors of these herbicides, no matter what their volatility. Although the sacks and seeds smelled very strongly in many cases, no effect on normal germination could be detected.

Table 2 shows the effects on germination when seeds were exposed to herbicide fumes for 1 day or for 4 days after storage of the seeds at high relative humidity for 1 day. Column 4 shows the percentage germination of the seeds after they had been aerated

TABLE 1—The percentage of "probable live seed" in dry alfalfa seed samples exposed to saturated atmosphere of the herbicides over various periods

	Vernal seed				Michigan seed
Herbicide	1 day	4 days	7 days	13 days	1 day
Esteron 10-10(2, 4-D)	95	96	90	95	94
Esteron 99(2, 4-D)	96	97	96	96	94
MCP amine	90	94	96	93	93
Premerge(DNBP)	94	97	97	91	97
2-4-D amine	93	100	95	99	93
Esteron 44(2, 4-D)	93	99	85	95	95
Esteron 245(2, 4-5-T)	96	100	95	95	92
Dalapon	93	95	88	94	94
Check	95	94	97	95	97
Check	98	..	96	..	91
Check	95	..	97	..	93
Check	100	..	..	..	95

TABLE 2—Percentage of probable live seed after exposure to fumes following 1 day in damp air

Herbicide	1 day	4 days	13 days plus 24 days aeration
Esteron 10-10(2, 4-D).....	94	100	90
Esteron 99(2, 4-D).....	58	89	54
MCP amine.....	87	94	71
Premerge(DNBP).....	84	89	100
2-4-D amine.....	93	88	96
Esteron 44(2, 4-D).....	49	52	61
Esteron 245(2, 4-5-T).....	86	78	94
Check*.....	93	99	96
Check*.....	95	..	96

*Check exposed for 1 day only in damp air, thereafter in dry air.

for 24 days, following 13 days exposure to herbicide fumes after 1 day of damp storage.

From the results given in Table 2, it appears that considerable damage was done to seeds by the fumes of Esteron 99 and Esteron 44 after the seeds had been stored for 1 day at a high relative humidity which dampened them slightly. These two preparations were designated by Professor Churchill as the most volatile. Aeration of such treated seeds did not appear to reduce the damage to any great extent. Lesser damage may have been done by Esteron 245 and by MCP amine.

DISCUSSION AND SUMMARY

From the figures given, it appears that alfalfa seed in a fully "air-dry" condition and in dry air may completely escape injury when stored at room temperature in an atmosphere saturated with herbicide fumes.

Storage of the seeds for 1 day in an atmosphere with very high relative humidity, however, made them considerably susceptible to injury from herbicide fumes. The comparatively volatile Esteron 99 and Esteron 44 2, 4-D herbicides were clearly more harmful than were the less volatile preparations. Aeration of the seeds after such exposure seemed to have little effect in dissipating the volatile chemical and in reducing injury to germination.

GIBBERELLIN AND HIGHER PLANTS: II.

INDUCTION OF FLOWERING IN BIENNIALS

By M. J. BUKOVAC and S. H. WITTWER

DEPARTMENT OF HORTICULTURE

LANG[1] first suggested that gibberellin[2] may replace the cold or vernalization requirement for flowering in a biennial. Flower induction, or a hastening of flowering by treatment of other biennial crops with gibberellin, has since been reported[3]. This paper summarizes the effects of gibberellin on the flowering of several biennial vegetable crops.

EXPERIMENTAL PROCEDURE

Experiments were begun in the spring of 1956 and continued through the winter and early spring of 1957. Representative plants of each crop variety were grown in pot cultures of soil in the greenhouse and maintained when possible at night temperatures of both 10 to 13 and 15 to 18 C. Higher, but never lower, temperatures than those indicated were often encountered, especially during daylight hours. The lower temperature (10 to 13°C.) was partially inductive for some crop varieties and noninductive for others; 15 to 18°C. proved noninductive, in the absence of gibberellin, for flowering with all biennials studied.

Gibberellin was applied either by placing droplets of a water solution on the growing tips of the plants or as an aqueous spray to the foliage. Tween-20 (0.1 percent) was added as a wetting agent. Treat-

[1]Lang, A. (1956). Induction of flower formation in biennial *Hyoscyamus* by treatment with gibberellin. Die Naturwiss. 43: 284-285.

[2]Gibberellic acid (Gibberellin X) and a mixture of gibberellins A and X were used in these studies. Samples were generously supplied by the Chas. Pfizer Co., Eli Lilly and Co., and Merck and Co. No differences, qualitative or quantitative, in flowering responses induced in plants by the various gibberellin preparations have thus far been noted.

[3]See Blaney, L. T. (1957). Gibberellic acid shortens biennial flowering time. Oregon State College Ornamental and Nursery Digest 1: 5; Lang, A. (1956). Gibberellin and flower formation. Die Naturwiss. 43: 544; Wittwer, S. H., and M. J. Bukovac (1957). Gibberellins—new chemicals for crop production. Michigan Agr. Expt. Sta. Quart. Bul. 39: 469-494.

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ment was begun when the plants were at a stage, determined by leaf number, stem or root size, at which exposure to cold would have resulted in a prompt flowering response.

Quantities of gibberellin, frequency of treatment and method of application (whether applied locally on the meristem or as a foliar spray) varied with each crop to obtain what were considered, from preliminary studies, optimum levels for promoting flowering.

Each treatment consisted of 3 to 12 single plant replicates. Stem heights were recorded weekly, and the appearance of visible flower primordia was checked daily. In general, treated plants showed remarkable uniformity in stem elongation and in appearance of visible flower primordia.

RESULTS

Carrots (*Daucus carota*, var. sativa): The most conclusive example of induction of flowering in a biennial with gibberellin thus far has been obtained with carrots. Weekly applications to the stem apices of 10 to 20 micrograms for 6 to 10 successive weeks resulted in 100 percent flowering in initial tests with plants grown above 16°C. This was at least 4 to 6 degrees above the maximum inductive temperature for flowering in carrots.

Flower induction after treatment with gibberellin often occurred when the roots were only one-half to 1 centimeter in diameter at the time of the first treatment.

Single applications of 20, 50, or 100 micrograms of gibberellin to the new top growth of large roots (2 to 4 centimeters in diameter) resulted in flowering of a high percentage of the treated plants.

The plants from which the data in Table 1 were obtained were grown from roots removed from the field in October where partial cold induction had already occurred. This accounted for 25 percent flowering in the absence of gibberellin treatment. Flowers on treated plants were normal and set seed profusely when insect pollinated; growth of the progeny was indistinguishable from those grown from seed of the controls.

In other experiments, Imperator and Chantenay carrots[4] were grown at 18°C. (night temperature). Single or repeated foliar sprays of 100 parts per million (p.p.m.) of gibberellin were applied. Treatment was started when the plants had roots 3 to 5 millimeters in

[4]The assistance of Michael H. Dickson, department of horticulture, Michigan State University, in providing the plants for these studies is gratefully acknowledged.

diameter and 8 to 10 true leaves had formed. Three, four or five sprays at 2-week intervals produced 100 percent bolting and subsequent flowering. Single sprays (100 p.p.m.) resulted in 50 to 75 percent flowering. No flowering occurred with plants not treated with gibberellin.

TABLE 1—Flowering response of carrot (var. Imperator) to treatment with gibberellin (each value a mean of eight single plant replications)

Measurement	Micrograms of gibberellin per plant			
	0	20	50	100
Days from transplanting to first visible flower primordia (means only of plants which flowered)..	83	98	95	94
Percent of plants which flowered.....	25	50	57	86
Seedstalk height at appearance of flower primordia (centimeters).....	27	40	34	61

Cabbage (*Brassica oleracea*, var. capitata): Flowering in cabbage normally occurs only after a prolonged cold period (4°C. for 8 weeks) to which the plants are exposed after the stems reach a diameter of 1 centimeter or more. In the present experiments, seedlings of Golden Acre and Ferry's Round Dutch were started September 26 and plants of each maintained thereafter at both 10 to 13 and 15 to 18°C. On November 9, when the plants had a stem diameter of about 1 centimeter, 100 micrograms of gibberellin were applied weekly for 8 weeks to the apices of one-half (six) of the plants of each variety at each temperature.

Extensive stem elongation occurred promptly with all treated plants, regardless of temperature. An occasional gibberellin-treated plant flowered at the higher (15 to 18°C.) temperature, and about one third of the treated plants of each variety eventually flowered. All produced elongated stems over 300 centimeters. Without gibberellin, plants of both varieties developed firm heads and the stems did not elongate.

The comparative growth and reproductive responses of the two varieties grown at the lower (10 to 13°C.) temperature are recorded in Table 2. With Golden Acre, the days to flowering were greatly reduced by gibberellin treatment; all plants became reproductive.

TABLE 2—Flowering and growth response of cabbage to gibberellin: plants grown at a night temperature of 10 to 13°C. and 9- to 11-hour photoperiod (each value a mean of six single plant replications)

Measurement	Variety			
	Golden Acre		Ferry's Round Dutch	
	Control	Gibberellin*	Control	Gibberellin*
Days from seeding to first visible flower primordia.....	157	129	No flowering	128
Percent of plants which flowered	67	100	0	100
Seedstalk height 167 days after seeding (centimeters).....	31	312	0†	265

*100 micrograms applied weekly (8 weeks) to the apices. First treatment applied November 9, 1956, when the plants were at the seven- to nine-leaf stage, and stem diameters were about 1 centimeter.
†Plants firmly headed.

Two thirds of the non-treated plants also flowered eventually. Flowering in all gibberellin-treated plants was preceded by extensive stem elongation (up to 400 centimeters); in the controls, flowerbud development and seedstalk elongation occurred simultaneously. Non-flowering controls of the Golden Acre variety developed loose heads.

A clearly defined effect of gibberellin on the flowering of Ferry's Round Dutch Cabbage was shown when this variety was grown at 10 to 13°C. (Table 2). Complete flower induction occurred with gibberellin. In the absence of gibberellin, plants developed firm heads and were completely vegetative. As at 15 to 18°C., extensive stem elongation preceded the appearance of flowerbuds on the gibberellin-treated plants (Fig. 1-A). After appearance of the terminal inflorescence, numerous flowerbuds developed from the lower axillary buds. Flowers appeared normal and set seed when pollinated.

Kale (*Brassica oleracea* var. acephala and pabularia): Plants of Dwarf Blue Curled (var. acephala) and Siberian (var. pabularia) were started as seedlings September 26. They were maintained thereafter at temperatures of 10 to 13 and 15 to 18°C. As with cabbage, weekly treatments with gibberellin (100 micrograms per plant applied to the stem apices) were begun November 9 when the plants were in the seven- to nine-leaf stage and continued thereafter for 8 weeks.

Fig. 1. Gibberellin-induced flowering responses in *Brassica* species grown at 10 to 13°C. Control plants are on the left; treated plants on the right.

A—cabbage (*Brassica oleracea* (capitata), var. Ferry's Round Dutch; B—kale (*Brassica oleracea* (acephala), var. Dwarf Blue Curled; C—collards (*Brassica oleracea* (acephala), var. Georgia; D—rutabaga (*Brassica napobrassica)*, var. Purple Top.

TABLE 3—Response of kale grown at 10 to 13°C. (night temperature) and a 9- to 11-hour photoperiod to treatment with gibberellin (each value a mean of six single plant replications)

Measurement	Variety			
	Dwarf Blue Curled		Siberian	
	Control	Gibberellin*	Control	Gibberellin*
Days from seeding to first visible flower primordia.....	No flowering	117	No flowering	134
Percent of plants which flowered	0	67	0	100
Seedstalk height 153 days after seeding (centimeters).....	0	137	0	81

*Apices treated with 100 micrograms weekly for 8 weeks, beginning when the plants were at the seven- to nine-leaf stage.

Whereas extensive stem elongation on gibberellin-treated plants occurred at both temperatures and control plants remained acaulous, flower induction with gibberellin occurred only with the plants grown at 10 to 13°C. (Table 3).

Fig. 1-B shows the typical contrast in plant development between gibberellin-treated and nontreated Dwarf Blue Curled kale. As with cabbage, flowerbuds appeared only after considerable stem elongation. The flowers were normal and set seed when pollinated.

Turnips (*Brassica rapa*) and rutabaga (*Brassica napobrassica*): Seed of two varieties of turnips, Purple Top and Extra Early White, and Purple Top rutabaga were sown October 30. The plants were grown thereafter at temperatures of 10 to 13 and 15 to 18°C. Gibberellin (1,000 p.p.m. in water solution) was applied as a foliar spray at the stages of plant development (leaf numbers) given in Table 4. Two or three foliar sprays were enough to induce marked stem elongation and hastened flowering by 24 to 44 days at 10 to 13°C.

Induction of flowering with gibberellin did not occur, but stems elongated on plants grown at a night temperature of 15 to 18°C. However, all gibberellin-treated rutabaga and turnip plants grown at 10 to 13°C. flowered and produced seed (Table 4, and Figs. 1-D and 2).

Except for Purple Top turnip, plants sprayed two or three times with 1,000 p.p.m. of gibberellin flowered with equal rapidity. Three spray applications at 2-week intervals resulted in significantly earlier

Fig. 2. Effects of temperature and gibberellin on the growth and flowering of beets (upper) and turnips (lower photograph). The two plants of each crop on the left were grown at 15 to 18°C., while the two on the right were grown at 10 to 13°C. Gibberellin was applied to plants second from left, and to those on the right.

Note that stems of all gibberellin-treated plants elongated, while only those grown at 10 to 13°C. elongated and flowered.

TABLE 4—Flowering response of turnip and rutabaga grown at 10 to 13°C. (night temperature) to treatment with gibberellin (each value a mean of three single plant replications)

Crop and variety	Times sprayed with gibberellin	Leaf number when first treated	Seedstalk heights when flowerbuds appeared	Time from seeding to first visible flower primordia
	(1,000 p.p.m.)		(centimeters)	(days)
Turnip.....	Control	—	0	157
Purple Top.	2	10 to 12	15	130
	3	7 to 9	97	113
Extra Early	Control	—	0	152
White.....	2	10 to 12	16	128
	3	7 to 9	71	122
Rutabaga.....	Control	—	0	No flowering
Purple Top.				up to 162 days
	2	6 to 7	31	132
	3	5 to 6	53	133

reproductive development with this variety (Table 4). Seedstalks at the time visible flowerbuds appeared were much taller on all plants that received three in contrast to two sprays of gibberellin.

Collards (*Brassica oleracea*, var. acephala): As with cabbage and kale, collards (vars., Georgia and Louisiana Sweet) were started from seed September 26 and maintained thereafter at night temperatures of 10 to 13 and 15 to 18°C. Plants were first treated November 9 with 100 micrograms of gibberellin applied to the stem apices. The treatment was repeated at weekly intervals for 5 weeks.

Extensive stem elongation occurred with all plants treated with gibberellin. At a night temperature of 15 to 18°C., 25 to 50 percent of the gibberellin-treated plants of both varieties flowered; all controls remained vegetative. Plants treated with gibberellin and grown at 10 to 13°C. produced visible flowerbuds 14 to 20 days earlier than the controls (Table 5) and produced seedstalks three to five times taller (Table 5, and Fig. 1-C).

Beet (*Beta vulgaris*): Seeds of three varieties (Crosby Egyptian, Detroit Dark Red and Perfected Detroit) were planted October 30. The seedlings were maintained at 10 to 13 and 15 to 18 C. At the 8- to 10-leaf stage, a foliar spray of 1,000 p.p.m. of gibberellin was

Fig. 3. Effects of gibberellin on the development of Utah 10-B celery grown at a night temperature of 15 to 18°C. Left, control (not treated); right, 100 micrograms of gibberellin applied weekly for 20 consecutive weeks. Occasionally, treated plants flowered after seed-stalks reached a height exceeding 150 centimeters.

TABLE 5—Response of Georgia and Louisiana Sweet collards grown at 10 to 13°C. (night temperature) and a 9- to 11-hour photoperiod to treatment with gibberellin (each value a mean of six single plant replications)

Measurement	Georgia		Louisiana Sweet	
	Control	Gibberellin*	Control	Gibberellin*
Days from seeding to first visible flower primordia.....	104	90	112	92
Percent of plants which flowered	100	100	83	100
Seedstalk height 122 days after seeding (centimeters).....	65	181	29	146

*Apices treated with 100 micrograms weekly for 5 weeks, beginning when the plants were at the seven- to eight-leaf stage.

applied to four to six plants of each variety at each temperature. The application was repeated after 2 weeks. A comparable number of nontreated plants were maintained as controls.

Extensive stem elongation in the absence of flowering occurred at the higher (15 to 18°C.) temperature, with both stem elongation and flowering at the lower (10 to 13°C.) temperature (Fig. 2). No flowering or stem elongation was evident in the controls at either temperature. Root size was reduced in all gibberellin-treated plants.

Similar results were obtained with gibberellin applied to sugar beets grown at a high (18°C.) temperature. The response at a temperature somewhat closer to critical temperatures for flower induction was not determined.

Celery (*Apium graveolens*, var. dulce): Plants of varieties, Summer Pascal (Waltham strain) and Utah 10-B were started from seed June 6 and maintained in a greenhouse thereafter at a night temperature of 18°C. or above. At the 12- to 15-leaf stage, 100 micrograms of gibberellin were applied weekly for 20 consecutive weeks to 12 plants of each variety. An equal number of nontreated plants were maintained as controls.

Gibberellin induced marked stem elongation (Fig. 3), but only an occasional plant flowered. When flowering did occur, it was only after the stems of treated plants had elongated over 150 centimeters. The effects of gibberellin on the flowering of celery grown at temperatures (10 to 13°C.) approaching those that would be inductive for flowering was not determined.

SUMMARY AND CONCLUSIONS

Several biennials grown at temperatures (10 to 13°C.) slightly above the critical temperature for flower formation were induced to flower with gibberellin. Among the vegetable crops which have thus far responded are carrots, beets, cabbage, kale, collards, and rutabagas. With the exception of Golden Acre cabbage and the two varieties of collards and turnips, all nontreated experimental plants remained vegetative when grown at a night temperature of 10 to 13°C.

At a night temperature of 15 to 18°C., gibberellin induced flowering in carrots; with all other biennials grown at 15 to 18°C., either no flowering occurred (beets, turnips, rutabagas, kale), or only a small percentage flowered (cabbage, celery, collards).

All gibberellin-treated plants produced greatly elongated stems, and considerable stem elongation preceded the appearance of flower-buds in the plants which flowered.

Thus, we conclude that gibberellin definitely promotes flowering in those plants (biennials) which have a low temperature requirement for flowering. However (with the possible exception of carrots), complete induction of flowering did not occur unless the plants were grown at temperatures approaching those normally inductive for flowering.

Results suggest that the normal cold requirement for flowering in biennials may be partially or, in few instances, completely replaced by the application of one or several foliar sprays of 100 to 1,000 p.p.m. or by weekly dosages of 100 micrograms of gibberellin to the stem apices. Such a means of controlling reproduction in biennials, previously regulated by temperature, will likely extend the boundaries wherein many flower and seed crops may be grown commercially.

Biennials induced to flower by gibberellin produced normal flowers and set seed when pollinated.

At this writing, the vegetative growth and reproductive development of progeny grown from seed harvested from treated plants is under evaluation.

GIBBERELLIN AND HIGHER PLANTS: III.

INDUCTION OF FLOWERING IN LONG-DAY ANNUALS GROWN UNDER SHORT DAYS

By S. H. WITTWER and M. J. BUKOVAC

DEPARTMENT OF HORTICULTURE

AMONG PLANT RESPONSES previously not generally subject to chemical regulation is flower induction in long-day plants grown under short photoperiods. Possible control of this photoperiodic response by gibberellin has been suggested by several recent reports.[1]

This paper reports the effects of gibberellin on the development of long-day annuals grown under environments not conducive to flowering. In the present investigations, representative varieties of several genera and species classically recognized as long-day plants, if grown at night temperatures of 10 to 13°C., comprised the experimental material.

METHODS AND MATERIALS

All plants were started from seed[2], maintained in soil cultures at high fertility levels, and grown under greenhouse conditions. Most of the studies were conducted during the fall and winter of 1956-57 when the normal photoperiod varied from 9 to 11 hours and night temperatures could be controlled.

Studies of the responses of long-day plants to gibberellin grown under long days and at high temperatures (15 to 25°C. night temperature) were made possible by supplemental lighting which extended the normal photoperiod to 18 hours, and by observing plant response during the summer months of 1956 at the prevailing seasonal temperatures and daylengths at East Lansing, Michigan.

[1]See Literature Cited, page 672.

[2]The assistance of the Ferry Morse Seed Company, Detroit, Michigan, in supplying seed of the crops tested in this and other gibberellin studies is gratefully acknowledged.

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Plants were treated either by placing measured droplets of water solution of gibberellin on the apices, or by applying an aqueous spray to the foliage. Each treatment consisted of 3 to 12 single plant replicates for each variety.

Weekly measurements of stem elongation, days to visible flowerbuds, and final seedstalk heights were recorded. All long-day plants grown under short days and at 10 to 13°C. night temperatures (with the exception of mustard and Tendergreen and Grand Rapids lettuce) remained vegetative and acaulous in the absence of gibberellin. Thus, measurements of reproductive responses of plants under short days were, in most cases, confined to gibberellin-treated plants; evaluation of variance between treated and nontreated plants was not possible.

RESULTS

Lettuce *(Lactuca sativa* and *Lactuca dentata):* Initial studies on the effects of gibberellin with head lettuce (var. Great Lakes) were conducted during the spring and summer months of 1956. Under the prevailing long days and moderately high temperatures, marked stem elongation and earlier flowering were induced. Gibberellin-treated plants formed no heads, but bolted and produced flower primordia 4 weeks earlier than plants not treated.

Subsequently, the effects of gibberellin as influenced by temperature and photoperiod were studied on several varieties of lettuce, representing distinct types. Plants were subject to a 9- to 11-hour daylength and night temperatures of 10 to 13°C. This environment induced the varieties Tendergreen and Grand Rapids to eventually flower, but it was noninductive for Great Lakes and Bibb. Under these conditions, all varieties were induced to bolt and flower with gibberellin. The response was most rapid with Tendergreen and Grand Rapids, and greater stem elongation occurred on treated plants before the appearance of the flowerbuds than it did on the controls.

By contrast, the response of Great Lakes and Bibb to gibberellin was distinct. No flowering or stem elongation occurred on nontreated plants. Nontreated Great Lakes produced firm heads, and Bibb remained as a rosette (Figs. 1-A, 1-B). Forty and 60 micrograms of gibberellin per plant (20 micrograms at 4-week intervals) were required for induction of flowering in Bibb and Great Lakes, respectively. Marked stem elongation, however, was induced in both varieties by 20 micrograms (Table 1).

TABLE 1—The effects of gibberellin on days to first visible flower primordia and seedstalk height of lettuce varieties; all plants grown under a short (9- to 11-hour) photoperiod and at night temperatures of 10 to 13°C. (each value a mean of six plants)

Variety	Days from seeding to first visible flower primordia			Seedstalk height (centimeters)		
	(Micrograms of gibberellin per plant)					
	0	20	40	0	20	40
Tendergreen....	74	67	68*	71	117	125
Grand Rapids...	112	108	92*	41	93	153
Great Lakes.....	No flowering		130†	No elongation	35	60
Bibb.....	No flowering		88*	No elongation	42	114

*Each plant received two 20 microgram applications of gibberellin at 4-week intervals.
†Each plant received three 20 microgram applications of gibberellin at 4-week intervals.

Seed harvested from gibberellin-treated Tendergreen, Grand Rapids, and Great Lakes lettuce plants germinated normally, and the growth of the progeny was indistinguishable from those grown from seed of the controls.

Several rosetted plants of *Lactuca dentata*, grown at 10 to 13°C. and a 9- to 11-hour photoperiod, were sprayed January 17, 1957, with 100 p.p.m. of gibberellin. Fig. 1-C compares the reproductive response, 4 weeks later, of treated and nontreated plants.

Endive *(Cichorium Endivia)*: Green Curled and Batavian endive were seeded September 26. After emergence, 12 plants of each variety were maintained under two separate environments: (a) at 10 to 13°C. and a 9- to 11-hour photoperiod; and (b) at 15 to 18°C. and an 18-hour photoperiod. On November 9 when the plants had 8 to 10 true leaves, and at weekly intervals thereafter for 8 weeks, 100 micrograms of gibberellin were applied to the apices of half (six) of the plants of each variety under each environment.

Extensive stem elongation occurred with all gibberellin-treated plants, although bolting began earlier and proceeded more rapidly at 15 to 18°C. and an 18-hour photoperiod (Fig. 2). Here also, the

Fig. 1. Gibberellin-induced flowering of lettuce and endive grown at a 9- to 11-hour photoperiod and a night temperature of 10 to 13°C.

A. Head lettuce (*Lactuca sativa,* var. Great Lakes); left, control; right, 60 micrograms of gibberellin applied as 20-microgram treatments to the stem apex at 4-week intervals.

B. Bibb *(Lactuca sativa);* left, control; center, 20; and right, 40 micrograms of gibberellin.

C. *Lactuca dentata;* left, control; right, an aqueous spray of 100 p.p.m. of gibberellin applied 4 weeks before photographing.

D. Endive (*Cichorium Endivia,* var. Green Curled); left, control; right, 100 micrograms of gibberellin applied weekly for 8 weeks.

TABLE 2—Gibberellin effects on the flowering of Green Curled and Batavian endive as influenced by photoperiod and temperature (each value a mean of six single plant replications)

Variety and treatment	10 to 13°C. 9- to 11-hour photoperiod		15 to 18°C. 18-hour photoperiod	
	Days from seeding to first visible flower primordia	Seedstalk height (centimeters)	Days from seeding to first visible flower primordia	Seedstalk height (centimeters)
Green Curled				
Control	No flowering	0	122	86
Gibberellin	166	174	104	236
Batavian				
Control	No flowering	17	127	52
Gibberellin	164	138	108	199

stems elongated and all plants flowered. Gibberellin-treated plants, however, flowered about 3 weeks earlier on greatly elongated seedstalks (Table 2).

At 10 to 13°C. and a 9- to 11-hour photoperiod, no flowering occurred in the absence of gibberellin. There was no stem elongation in the Green Curled variety and only slight bolting in Batavian (Table 2). All treated plants of both varieties flowered (Fig. 1-D) but at a later date than plants grown at the high (15 to 18°C.) temperature and long (18-hour) photoperiod (Fig. 2). Green Curled and Batavian endive, as with Grand Rapids and Bibb lettuce, were specifically induced to flower under a noninductive environment.

Mustard *(Brassica juncea):* Tendergreen mustard was started from seed September 26, and thereafter subjected to the two temperature-photoperiod combinations described above for endive. The initial treatment of 100 micrograms of gibberellin was applied to the apices of half (six) of the plants of each variety at each environment on November 9. Plants then had 8 to 10 true leaves. The treatment was repeated weekly for 3 weeks.

All mustard plants eventually flowered regardless of temperature, photoperiod, or gibberellin. The effects of each are summarized in Table 3. Plants treated with gibberellin flowered 9 to 29 days earlier, depending on temperature and photoperiod. Seedstalks were several times taller in gibberellin-treated plants (Fig. 3-A), and stems often elongated 40 to 60 centimeters before flowerbuds were visible. At

10 to 13°C. and a 9-hour photoperiod, visible flowerbuds developed on control plants which were practically acaulous with stems only slightly elongated (Table 3).

Fig. 2. Vegetative and reproductive responses of endive (*Cichorium Endivia*, var. Green Curled) to temperature, photoperiod and gibberellin.

A. 10 to 13°C. night temperature and a 9- to 11-hour photoperiod.

B. Same as A plus gibberellin.

C. 15 to 18°C. night temperature and an 18-hour photoperiod.

D. Same as C plus gibberellin.

TABLE 3—Effect of gibberellin on the reproductive development of mustard (var. Tendergreen) grown at different temperatures and photoperiods

Measurement	10 to 13°C. 9-hour photoperiod		15 to 18°C. 18-hour photoperiod	
	Control	Gibberellin	Control	Gibberellin
Days from seeding to first flower primordia.....	117	88	81	72
Seedstalk heights (centimeters).	11*	118*	25†	67†

*122 days after seeding.
†87 days after seeding.

Radish *(Raphanus sativus):* Varieties Early Scarlet Globe, Crimson Giant, Icicle and Comet were started from seed September 15, and grown thereafter at the same temperatures and photoperiods previously described for endive. Gibberellin (a single application of 100 micrograms per plant) was applied October 10 to the apices of half (12) the plants of each variety grown under the two environments.

Table 4 lists records of flowering and seedstalk heights. The data for radish parallel those for endive. Marked stem elongation occurred with all gibberellin-treated plants. Bolting and flowering were earlier at 15 to 18°C. and an 18-hour photoperiod than at the lower temperature and shorter day. With the exception of Icicle, all varieties flowered earlier at the high temperature and under long days when treated with gibberellin.

The specific effect of gibberellin on the flowering of radish was noted at 10 to 13°C., and a 9- to 11-hour photoperiod. With gibberellin, all plants flowered; without it, all remained vegetative (Fig. 3-B and Table 4). The hypocotyl-stem elongation in the controls was not accompanied by flower formation.

Spinach *(Spinacia oleracea):* Two varieties, Dark Green Prickly Seeded and Bloomsdale were seeded December 1 and maintained thereafter at 10 to 13°C. and a 9- to 11-hour photoperiod. Plants were sprayed with 100 or 1,000 p.p.m. of gibberellin at the growth stages (leaf numbers) given in Table 5. Six weeks after the first application, a second spray was put on.

As with Bibb and Great Lakes lettuce grown under a similar environment, a single gibberellin application promoted stem elongation (20 to 40 centimeters), but the plants did not flower. Flowering

Fig. 3. Gibberellin-induced flowering in typical long-day plants. Controls are on the left, gibberellin-treated plants on the right.

A. Mustard (*Brassica juncea*, var. Tendergreen); B. Radish (*Raphanus sativus*, var. Comet); C. Spinach (*Spinacia oleracea*, var. Dark Green Prickly Seeded); D. Dill (*Anethum graveolens*).

TABLE 4—Effects of gibberellin on flowering of four varieties of radish grown at different temperatures and photoperiods

Variety	10 to 13°C.—9- to 11-hour photoperiod				15 to 18°C.—18-hour photoperiod			
	Days to flower primordia		Seedstalk heights*		Days to flower primordia		Seedstalk heights†	
	Control	Gibberellin	Control (centimeters)	Gibberellin (centimeters)	Control	Gibberellin	Control (centimeters)	Gibberellin (centimeters)
Early Scarlet Globe	No flowering	106	14	52	74	65	37	67
Crimson Giant		112	15	47	92	65	13	78
Icicle		127	7	26	72	73	17	63
Comet		132	7	18	88	67	13	50

*135 days after seeding.
†79 days after seeding.

occurred on all of the plants of the Dark Green Prickly Seeded variety grown at 10 to 13°C. and a 9- to 11-hour photoperiod and subjected to repeated applications of either 100 or 1,000 p.p.m. of gibberellin (Table 5).

These plants, however, became reproductive only after considerable stem elongation, and the time of initial treatment with gibberellin was of little consequence. Nontreated plants, under the same conditions, remained as vegetative rosettes (Fig. 3-C). Results similar to those given in Table 5 for the Dark Green Prickly Seeded variety were obtained with Bloomsdale, except that the gibberellin-induced flowering occurred about 2 weeks later.

With the same varieties grown at 15 to 18°C. and an 18-hour photoperiod, flowering occurred in all plants and at an earlier date, with no differences attributable to gibberellin.

Dill *(Anethum graveolens):* Dill, a very sensitive long-day plant both in terms of stem elongation and flowering, was seeded November 5 and grown thereafter at a 9- to 11-hour photoperiod and at night temperatures of 10 to 13°C. and 15 to 18°C. A single foliar spray of 100 p.p.m. of gibberellin was applied at the growth stages (leaf numbers) indicated in Table 6.

Gibberellin specifically induced dill to flower when grown at a noninductive short photoperiod (Fig. 3-D). The response to gibberellin occurred either at low (10 to 13°C.) or high (15 to 18°C.) temperatures. Plants grown at the higher temperature flowered in fewer numbers of days, however, and produced taller seedstalks than at

TABLE 5—The effects of foliar sprays of gibberellin on the flowering of Dark Green Prickly Seeded spinach grown at 10 to 13°C. and a 9- to 11-hour photoperiod (each value a mean of six plants)

Gibberellin (p.p.m.)	Leaf number when initially treated	Days from seeding to first flower primordia	Seedstalk height (centimeters)
Control (no gibberellin)	....	No flowering	0
100 p.p.m. repeated after 6 weeks	2—3	108	80
	4—5	106	99
	6—7	107	88
1,000 p.p.m. repeated after 6 weeks	2—3	94	118
	4—5	105	119
	6—7	101	108

TABLE 6—Flowering response of dill grown under a short (9- to 11-hour) photoperiod to gibberellin (100 p.p.m. as foliage spray) applied at various stages of plant development (each value a mean of three plants)

Leaf number of plant when treated	10 to 13°C.		15 to 18°C.	
	Days to flower primordia	Seedstalk height (centimeters)	Days to flower primordia	Seedstalk height (centimeters)
Control	No flowering	No elongation	No flowering	12
5—7	116	84	108	155
7—9	125	100	117	145
9—11	129	84	113	132
11—13	128	60	116	110

the lower temperature. Control plants did not flower nor did the stems elongate at 10 to 13°C.; at 15 to 18°C., slight stem elongation occurred, but flowerbuds were absent.

With dill grown under long (18-hour) photoperiods and a night temperature of 15 to 18°C., stem elongation and flowering became evident after four to five leaves had developed. Under such conditions, gibberellin (100 p.p.m. foliar spray) had no effect on flowering. Dill grown under a short photoperiod and appropriately treated with gibberellin developed reproductively the same as plants subjected to a long photoperiod.

SUMMARY AND CONCLUSIONS

Several long-day annuals grown under noninductive, short (9- to 11-hour) photoperiods showed marked stem elongation and were induced to flower and produce seed with gibberellin. Vegetable crops which showed a positive response included leaf and head lettuce, endive, radish, mustard, spinach, and dill. No plant sensitive to long days and appropriately treated with gibberellin failed to flower when grown at a short photoperiod.

Some long-day plants (lettuce, endive, radish and mustard) maintained under a long (18-hour) photoperiod and treated with gibberellin also flowered earlier than the nontreated controls. Others (spinach and dill) were not affected.

With long-day plants grown under short days, a single foliar spray of 100 or 1,000 p.p.m. or 20 to 100 micrograms of gibberellin per plant applied at various stages in seedling growth, induced flowering

(Grand Rapids and Tendergreen lettuce, radish, dill). Other crops (Bibb and Great Lakes lettuce, endive, mustard, spinach) required repeated treatments.

It is apparent that, with gibberellin, the photoperiodic requirement for flowering of many long-day plants may be subject to regulation; under long days, flowering and seed production may be accelerated. Thus, many long-day plants may now be induced to flower and produce seed under environments previously not suited for their culture. Studies are now in progress with other genera and species highly sensitive in their flowering responses to length of day.

LITERATURE CITED

Bünsow, R., and R. Harder (1956). Blütenbildung von Bryophyllum durch Gibberellin. Die Naturwiss. 43: 479-480.

Bünsow, R., and R. Harder (1956). Blütenbildung von *Lampsana* durch Gibberellin. Die Naturwiss. 43: 527.

Hamner, K. C., and A. W. Naylor (1939). Photoperiodic responses of dill, a very sensitive long day plant. Bot. Gaz. 100: 853-861.

Harder, R., and R. Bünsow (1956). Einfluss des Gibberellins auf die Blütenbildung bei *Kalanchoe blossfeldiana*. Die Naturwiss. 43: 544.

Harrington, J. F.; Lawrence Rappaport and K. J. Hood (1957). Influence of gibberellins on stem elongation and flowering of endive. Science 125: 601-602.

Lang, A. (1956). Gibberellin and flower formation. Die Naturwiss. 43: 544.

Lona, F. (1956). L'azione dell' acido gibberellico sull'accrescimento caulinare di talune piante erbacee in condizioni esterne controllate. Nuovo Gior. Bot. It. (n.s.) 63: 61-76.

Lona, F. (1956). Osservazioni orientative circa l'effetto dell'acido gibberellico sullo sviluppo riproduttiva di alcune longidiurne e brevidiurne. L'Ateneo Parmense 27: 867-875.

Lona, F., and A. Bocchi (1956). Caratteristiche d'accrescimento e sviluppo di alcume razze invernali di cereali trattate con acido gibberellico. Estratto dalla "Rivista Internazionale d' Agricoltura" 6: 44-45.

Wittwer, S. H.; M. J. Bukovac, H. M. Sell and L. E. Weller (1957). Some effects of gibberellin on flowering and fruit setting. Plant Physiol. 32: 39-41.

Wittwer, S. H., and M. J. Bukovac (1957). Gibberellins--new chemicals for crop production. Michigan Agr. Expt. Sta. Quart. Bul. 39: 469-494.

Wittwer, S. H., and M. J. Bukovac (1957). Gibberellin effects on temperature and photoperiodic requirements for flowering of some higher plants. Science 125: (In Press).

GIBBERELLIN AND HIGHER PLANTS: IV.

FLOWERING RESPONSES OF SOME FLOWER CROPS

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IN A COMPARATIVELY SHORT TIME, considerable interest has been aroused in gibberellin and, specifically, gibberellic acid. Until now, most of the reports on economic crops have dealt with vegetables and pasture grasses (Imp. Chem. Ind., 1955; Morgan and Mees, 1956; Leban and Barton, 1957). The unique effects of the chemical on flower induction in certain biennials and long-day annuals should make it useful in floricultural crop production (Wittwer and Bukovac, 1957).

A means of hastening maturity of flower crops would substantially reduce the cost of production and enable greenhouse flower growers in the north to compete successfully with their southern and western neighbors. This paper summarizes initial studies with gibberellin on the development and flowering of several greenhouse-grown flower crops.

METHODS AND MATERIALS

All experiments were conducted in the greenhouse during the fall and winter of 1956-1957. Plants were grown in soil cultures and exposed to seasonal short days and low sunlight conditions. Aqueous solutions containing gibberellin were prepared as needed, and a measured volume of a known concentration was delivered from a micropipette onto the growing tips (stem apices) or applied as a spray to the foliage. Plant heights were determined by using the cotyledonary plate of the stem as a base and measuring to the tip of the vegetative or reproductive bud.

Stocks *(Matthiola incana):* Weekly applications of 5 to 100 micrograms of gibberellin to the stem apices, or sprays of 10 to 1,000 parts

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Fig. 1. The effects of gibberellin on the flowering of stocks (*Matthiola incana*, var. No. 1 Lilac-Lavendar Improved). Top, controls (not treated); bottom, 20 micrograms of gibberellin applied to the stem apices at weekly intervals for 10 successive weeks. Plants were started from seed August 1 and treatments were begun September 18 when 10 to 12 leaves had formed.

per million (p.p.m.) resulted in marked stem elongation and hastened flowering 2 to 3 weeks.

Ten varieties of stocks at the 10- to 12-leaf stage were treated on September 18 with 5, 10, and 20 micrograms of gibberellin. Water solutions of gibberellin were applied to the stem apices of 10 plants of each variety. One week later, the treatment was repeated on half (five) of the plants, and weekly thereafter for 10 weeks. Plants treated weekly, regardless of concentration, attained a height of 130 to 140 centimeters; while the controls averaged 40 to 50 centimeters (Fig. 1).

Stocks (vars. Ball Supreme 22, Ball Dwarf White 5 and Ball White-Medium Tall 16) were seeded October 16, and grown at 15°C. (night temperature). Treatments were begun November 24 and repeated weekly thereafter for 3 weeks. Gibberellin-treated plants produced marketable spikes about 3 weeks earlier than the controls (Table 1 and Fig. 3, lower right).

TABLE 1—Flowering response of stock (Matthiola incana, var. Ball Supreme 22) to single and repeated applications of 20 micrograms of gibberellin per plant when grown at a night temperature of 15°C. (each value a mean of four single plant replications)

Measurements	Control (not treated)	Number of leaves when first treated									
		Single applications					Four applications				
		4	6	8	11	13	4	6	8	11	13
Heights of spikes (centimeters).....	65	84	79	74	79	85	85	77	81	79	80
Days from seeding to first open floret.....	119	94	101	106	104	99	94	99	100	104	104

Petunia *(Petunia hybrida):* Petunias (vars. Paleface and Summer Snow) were seeded November 9 and grown at 10°C. (night temperature) until February 15. They were then transferred to a night temperature of 15°C., and foliar sprays of 10, 100, and 1,000 p.p.m. of gibberellin were applied when the leaf rosette was 7 centimeters in diameter. Either a single treatment of 10 or 100 p.p.m. of gibberellin or two applications of 10 p.p.m. at a 2-week interval promoted earlier flowering. No excessive stem elongation was observed at these levels (Table 2). The varieties Gypsy (Fig. 2) and Gaity responded similarly to Paleface and Summer Snow (Fig. 3, upper left).

TABLE 2—Flowering responses of two petunia varieties to single foliar sprays of gibberellin: plants grown at a night temperature of 15°C. (each value a mean of 10 single plant replications)

Variety	Measurement	Gibberellin (p.p.m.)			
		0	10	100	1,000
Paleface					
	Height of plants (centimeters).....	7	11	12	21
	Days from seeding to first open flower..	143	138	139	133
Summer Snow					
	Height of plants (centimeters).....	7	10	13	15
	Days from seeding to first open flower..	141	136	134	133

Post (1955) has reported that rapid growth of petunia occurs in winter at 18°C., but it does not flower until April because of the preceding short days. In the present experiments, however, flowering was induced in petunia with gibberellin in midwinter and under short days. Varieties Blue Bedded Improved and Little Giant, treated during November, December, and January, flowered 3 to 4 weeks earlier than controls. Plants treated February 16 flowered 35 days later, regardless of whether single or repeated treatments were applied; this was 7 to 10 days earlier than plants not treated.

Fig. 2. Effects of gibberellin on the flowering of petunia (*Petunia hybrida*, var. Gypsy). Left, controls (not treated); right, a foliar spray containing 10 p.p.m. of gibberellin was applied 45 days before photographing.

Fig. 3. Gibberellin effects on the flowering of petunia (*Petunia hybrida*, var. Summer Snow), upper left; English daisy (*Bellis perennis*), upper right; China aster (*Callistephus chinensis*), lower left; and stock (*Matthiola incana*, var. Ball Dwarf White 5). Plants on the right were treated with single applications of gibberellin either as a foliage spray of 10 p.p.m. (petunia), or as 20 micrograms applied to the stem tips (English daisy, China aster, stock). Control plants are on the left.

Annual larkspur (*Delphinium ajacis*, var. Super Majestic Blue): The time formerly required for the successful production of larkspur in the greenhouse precluded its widespread use as a commercial crop. With gibberellin, however, days to flowering have been reduced (Table 3 and Fig. 4, lower left).

Larkspur was started from seed September 1, and the plants were held thereafter at 10 and 15°C. (night temperature). Twenty micrograms of gibberellin were first applied to the stem apices of plants grown at 10° C. on November 24; it was applied to those grown at 15°C. on December 15.

At this writing (April 10, 1957), gibberellin-treated plants at 10°C. had developed open flowers on spikes about 100 centimeters high. Without gibberellin, plants were much shorter (30 to 40 centimeters) and had few visible flowerbuds. At 15°C., the majority of the gibberellin-treated plants had flowered; only flowerbuds had appeared on the controls.

Fig. 4. The effects of gibberellin on the flowering of pansy (*Viola tricolor*, var. Superb Giant), upper left; forget-me-not (*Myosotis scorpioides*, var. Blue Bird), upper right; annual larkspur (*Delphinium ajacis*, var. Super Majestic Blue) lower left; and foxglove (*Digitalis purpurea*, var. Giant Shirley), lower right. Treated plants are on the right with the controls on the left.

TABLE 3—Effect of gibberellin on the flowering of larkspur (Delphinium ajacis, var. Super Majestic Blue) seeded September 1, 1956 and grown at night temperatures of 10 and 15°C. (each value a mean of four single plant replications)

Treatments	Leaf number at first treatment		Plants in which flowerbuds appeared (as of March 15, 1957)		Time from seeding to appearance of first flowerbuds of plants which flowered		Heights of plants (as of March 15, 1957)	
	10°C.	15°C.	(percent)		(days)		(centimeters)	
			10°C.	15°C.	10°C.	15°C.	10°C.	15°C.
Control	....	....	37*	100	...	187	21	59
Single application 20 micrograms	0—2	3—4	50	100	203	173	26	76
	2—3	4—5	75	100	203	173	40	98
	3—4	5—6	50	100	203	166	35	93
	4—5	6—7	100	100	203	178	33	74
Repeated applications 20 micrograms bimonthly for 2 months	0—2	3—4	100	100	187	164	86	133
	2—3	4—5	100	100	183	164	91	118
	3—4	5—6	100	100	188	164	63	113
	4—5	6—7	100	100	189	175	77	104

*Three out of eight plants produced flowerbuds after 203 days.

TABLE 4—Effects of single and repeated applications of gibberellin (20 micrograms per plant) on flowering of pansy (Viola tricolor, var., Superb Giant): plants grown at a night temperature of 15°C. (each value a mean of four single plant replications)

Treatments	Height of plants when first treated	Plants which flowered	Time from seeding to first open flower
	(centimeters)	(percent)	(days)
Control (not treated)	...	0	...
Single application	2	50	126
	2½	75	121
	3	25	136
Repeated applications bimonthly for 2 months	2	50	126
	2½	75	112
	3	75	123

Pansy (*Viola tricolor*, var. Superb Giant): Seed were sown November 5, and the plants grown thereafter at a night temperature of 15°C. When 2 to 3 centimeters in height (Table 4), 20 micrograms of gibberellin were applied to the stem apices. The percent of plants which flowered and days to flowering of plants subjected to the various gibberellin treatments are given in Table 4. Flowering was apparent as early as 25 days after a single application of 20 micrograms.

Control plants were decidedly less vigorous, did not flower, and showed no evidence of flowerbud formation (Fig. 4, upper left). Excessive stem elongation, however, was often noted on gibberellin-treated plants, especially at dosages exceeding 20 micrograms. When first treated, plants 2½ centimeters in height were most responsive in terms of percent of plants which flowered, and they flowered in fewer days.

Forget-me-not (*Myosotis scorpioides*, var. Blue Bird): Plants were started from seed November 5, and grown at a night temperature of 15°C. Single or five applications of 20 micrograms each of gibberellin, repeated at 2-week intervals, were applied to the stem apices beginning December 22. The result was earlier flowering, as well as increased stem elongation (Table 5 and Fig. 4, upper right).

Foxglove (*Digitalis purpurea*, var. Giant Shirley): Seed were sown October 7, 1956, and the plants grown thereafter at a night temperature of 15°C. Beginning December 15, 100 micrograms of gibberellin

TABLE 5—Effects of single and repeated applications of gibberellin (20 micrograms per plant) on flowering of forget-me-not (Myosotis scorpioides, var., Blue Bird): plants grown at a night temperature of 15°C. (each value a mean of four single plant replications)

Treatments	Plant heights when first treated	Plants which flowered	Time from seeding to first open flower	Heights of spikes
	(centimeters)	(percent)	(days)	(centimeters)
Control (no treatment).	...	No flowering	...	..
Single application.....	2.6	75	128	18
	3.9	25	123	15
Repeated applications bimonthly for 2 months	2.6	100	125	46
	3.9	100	128	34

were applied to the stem apex of each plant; the treatment was repeated five times at 2-week intervals. Plants were in the four-leaf stage when first treated. Flowering was induced by an accumulated dosage of 600 micrograms of gibberellin per plant (Fig. 4, lower right). Apparently, the necessary cold requirement for flowering can be satisfied in this biennial by appropriate treatment with gibberellin.

Other crops: In preliminary experiments, treatment with gibberellin has resulted in earlier flowering in China Aster *(Callistephus chinensis,* Fig. 3, lower left), as well as English daisy *(Bellis perennis,* Fig. 3, upper right), and Transvaal Daisy *(Gerbera jamesonii).*

SUMMARY AND CONCLUSIONS

Gibberellin, 20 micrograms applied to stem apices or a foliar spray of 10 to 100 p.p.m., hastened flowering 10 days to 4 weeks in stocks, petunia, larkspur, English daisy, China aster and gerbera when grown in the greenhouse during the fall and winter. At these dosages, earlier flowering without excessive stem elongation or any apparent harmful effect on market quality was observed.

Higher concentrations, 100 to 1,000 micrograms per plant or foliar sprays of 1,000 p.p.m., often resulted in greatly elongated and weakened stems. Foxglove, a cold-requiring biennial, was an exception in that 600 micrograms induced flowering without excessive stem elongation.

Stocks treated with gibberellin were considered superior to those not treated. The plants matured earlier and produced longer and more uniform flower spikes.

With pansy and forget-me-not, gibberellin treated plants flowered while controls remained vegetative.

LITERATURE CITED

Imperial Chemical Industries Limited (1955). Accepted patent application. Commonwealth of Australia. No. 10190-1955.

Leben, Curt, and Lela V. Barton (1957). Effect of gibberellic acid on growth of Kentucky bluegrass. Science 125: 494-495.

Morgan, D. G., and G. C. Mees (1956). Gibberellic acid and the growth of crop plants. Nature 178: 1356-1357.

Post, K. (1955). *Florist Crop Production and Marketing.* Orange Judd Publishing Company, Inc., New York. 891 pp.

Wittwer, S. H., and M. J. Bukovac (1957). Gibberellins—New chemicals for crop production. Mich. Agr. Expt. Sta. Quart. Bul. 39: 469-494.

GIBBERELLIN AND HIGHER PLANTS: V.

PROMOTION OF GROWTH IN GRASS AT LOW TEMPERATURES

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GIBBERELLIN IS KNOWN TO PROMOTE the growth of a wide variety of plants, including grass. A recently accepted patent application[1] in Australia deals with the use of gibberellin (gibberellic acid) applied as a spray in the spring to pasture plants.

Substantial increases in early yields were reported by the use of 1 to 2 ounces of gibberellin per acre, especially when it was used with nitrogen fertilizer. A desirable ratio of the active compound to nitrogen ranged from 1:320 to 1:640. It was further reported that gibberellin alone, or combined with fertilizer, resulted in growth under conditions of low light intensity and low temperature.

Additional details of these studies have been reported,[2] along with experiments on promoting autumnal growth of Kentucky bluegrass.[3] The possibilities of promoting earlier growth of grass in the north for earlier grazing of livestock, for hay or silage, and for growth in lawns and turf were immediately suggested.

EXPERIMENTAL PROCEDURE

On March 5, 1957, at East Lansing, Michigan, replicated plots of 15 square feet of predominantly Kentucky bluegrass *(Poa pratensis)* sod were sprayed with aqueous solutions containing 10, 100 and 1,000 p.p.m. of gibberellin. Additional plots were sprayed on March 13. The quantities of gibberellin applied approximated one-tenth, 1, and

[1]Imperial Chemical Industries Limited (1955). New organic compounds. Accepted patent application, Commonwealth of Australia, No. 10190-1955.

[2]Morgan, D. G., and G. C. Mees (1956). Gibberellic acid and the growth of crop plants. Nature 178: 1356-1357.

[3]Leben, Curt, and Lela V. Barton (1957). Effects of gibberellic acid on growth of Kentucky bluegrass. Science 125: 494-495.

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TABLE 1—Temperature records, in degrees centigrade, at East Lansing and Rochester, Michigan, during the period of March 6 to April 9, 1957 (each value a mean of five days)

Date	East Lansing			Rochester		
	Maximum	Minimum	Average	Maximum	Minimum	Average
March 6—10...	5	−6	−1	..	..	..
11—15...	16	3	10	..	..	..
16—20...	5	−3	1	..	..	..
21—25...	10	−3	4	12	0	6
26—30...	7	−2	3	10	0	5
April 1—4....	8	−1	4	12	2	7
5—9....	6	1	3	10	3	7
Means.....	8	−2	3	11	1	6

10 ounces, respectively, of the active chemical per acre, since the equivalent of 75 to 100 gallons of solution was applied.

At the time of treatment, there was no active growth; the sod was mostly brown with only a light shade of green showing through. Night temperatures after treatment averaged below freezing, with an average mean daily temperature of 3°C. (Table 1).

Within 5 days of both the March 5 and March 13 treatments, noticeable greening and growth of grass and broadleafed plants occurred in all the gibberellin-sprayed plots. This was followed by a rapid growth of the grass which turned a light green. The rate of growth and loss of dark green color was directly proportional to the concentration of gibberellin used (Table 2 and Fig. 1).

In other tests now in progress, it has been observed that gibberellin-treated grass retained its bright green color if soil fertility levels were high, or if heavily fertilized. If the dry weight values 35 days after treating (Table 2) are converted to pounds per acre, yields of 192, 509, and 796 pounds were realized within a 5-week period for the one-tenth, 1 and 10 ounces, respectively, of gibberellin applied. This was at a time of the year when low temperatures retarded growth almost completely in the non-treated plots, and temperatures at night dropped as low as -6°C.

Additional plots of various genera and species of grass were treated at the Ferry Morse Seed Company trial grounds near Rochester, Michigan on March 21.[4] An aqueous solution containing 100 p.p.m. of gib-

[4]Grateful acknowledgement is extended to Raymond Coulter and Harm Drewes of the Ferry Morse Seed Company for their cooperation in these studies.

TABLE 2—Effect of gibberellin on the growth of grass at low temperatures (each value a mean of two replications of five observations each)

Date of treatment and concentration	Height	Fresh weight	Dry weight
(p.p.m.)	(centimeters)	(grams per square foot)	
March 5		35 days after treating	
0	5	....	...
10	13	9.7	2.0
100	21	23.9	5.3
1,000	29	46.6	8.3
March 13		27 days after treating	
0	6	....	...
10	15	13.4	3.2
100	19	26.8	5.7
1,000	22	36.4	7.1

Fig. 1. The effect of gibberellin in promoting the growth of grass (predominantly *Poa pratensis*, var. Kentucky bluegrass) in early spring. Rectangular plots (15 square feet each) starting in the foreground and going toward the back were sprayed March 5, 1957, with aqueous solutions containing 1,000, 0, 100, 1,000, 10, 0, 100, 0, 1,000, 100, 10, 1,000, 0, 100, and 10 p.p.m., respectively, of gibberellin. Photographed April 1, 1957.

berellin, equivalent to 1 ounce per acre of the chemical, was applied as a spray to a 12-square foot area of each variety or species. Temperature records for that location from March 21 until April 9, when final observations were made, are given in Table 1.

The comparative low temperature growth responses of the various grasses are classified in Table 3. A marked growth response accompanied by a bright green color occurred with all species and varieties of *Poa* and with *Cynodon dactylon* (Bermuda-grass, Fig. 2). A noticeable greening and increased growth of *Agrostis* and *Festuca* species was also apparent, while *Lolium* species were only slightly responsive. The predominate components of grass mixtures for lawns were readily identified by their differential response to gibberellin at low temperatures. No promotion of growth could be detected in *Zoysia japonica*.

TABLE 3—Comparative low temperature growth responses of various grasses to gibberellin

Very responsive	Moderately responsive		Slightly responsive
Kentucky Bluegrass *Poa pratensis*	Red Top Fancy *Agrostis alba*	Creeping Red Fescue *Festuca rubra*	Domestic Rye *Lolium multiflorum*
Rough Stalked Bluegrass *Poa trivialis*	Highland Bent *Agrostis tenuis*	Illahee Fescue *Festuca rubra illahee*	Perennial rye *Lolium perenne*
Merion Bluegrass *Poa pratensis*	Seaside Bent *Agrostis palustris*	Chewings Fescue *Festuca rubra commutata*	Shady Lawn Mixed†
Delta Blue	Astoria Bent *Agrostis tenuis*	Kentucky 31 Fescue *Festuca elatior arundinacea*	Suburbanite†
Extra Fine Mixed*	Penn Lawn *Agrostis palustris*	Alta Fescue *Festuca elatior arundinacea*	
Fine Mixed*			
Bermuda Grass‡ *Cynodon dactylon*			

*Predominently *Poa* species.
†Predominently *Lolium* species.
‡At East Lansing, Michigan in cooperation with B. H. Grigsby.

SUMMARY AND CONCLUSIONS

Pronounced growth of grass in early spring, when growth would not have otherwise occurred, was induced with gibberellin. Quantities of the active chemical approximated one-tenth, 1, and 10 ounces per acre, with growth roughly proportional to the amounts applied. Treated grass turned lighter green in color when fertility levels were low, but it remained a bright green in soils of high fertility or if fertilizer was applied.

Fig. 2. The effect of gibberellin on the growth of Bermuda-grass *(Cynodon dactylon)*. Left, control (not treated); right, 2 ounces per acre of gibberellin applied April 16, 1957. Phtotographed April 26. Treated grass (on right) showed growth within 3 days and was dark green within 10 days. No growth or appearance of green occurred on the grass (left) which was not treated with gibberellin.

Poa species and Bermuda-grass were most responsive, followed by *Agrostis, Festuca* and *Lolium* in the order given. *Zoysia* did not respond.

Many far-reaching benefits may result from gibberellin applications to grass. Since growth is definitely promoted at temperatures otherwise too low for growth, earlier grazing of pastures in the north appears a reality. Winter cover crops may be established in cold weather.

For nurserymen, seedsmen, spring flower shows, and as a novelty for the amateur gardener, green turf may be produced weeks ahead of schedule.

KILLING UNDESIRABLE TREES — A COMPARISON OF METHODS

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MORE AND MORE ATTENTION is being given to the improvement of forest stands. Such improvement work usually involves the removal of undesirable trees which often cannot be marketed at a profit. The recommended procedure is usually to kill the undesired trees and leave them to deteriorate in place.

Several methods of killing trees are available, and this study was concerned with the amount of labor required by five different procedures. Each method was used on over 200 trees. The actual time spent on each tree was checked and is used as the basis for comparison. No attempt was made to determine the additional time consumed by equipment repair, transport of materials, moving between trees, and rest periods.

METHODS USED

The first method used a portable power girdling machine which is carried on the operator's back and is powered by a small air-cooled gasoline engine. This was a stock model and had not been altered in any way. It is powered by a 1.6 horsepower engine. The rotary cutterhead makes a U-shaped cut, about 1 inch wide and an inch and a half deep, around the tree.

The second method consisted of applying a silvicide as a basal spray to the tree trunk with a knapsack-style hand sprayer. A single fan spray nozzle was used on the sprayer. From 18 to 24 inches of the lower portion of the trunk, as well as any exposed roots, were covered to the point of runoff. The spray solution used was a 2,4-D and 2,4,5-T combination "brushkiller" product in diesel oil at a 2 percent concentration.

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In the third method, sodium arsenite solution was poured into small holes made in the base of the trunk with a special axe having an awl or punch on the back of the head. The axe is swung at an angle so that the holes slope downward and will hold the solution. The holes made by this method are about one-half inch in diameter and usually about 1 inch deep.

The fourth method used the same basal spray solution as the second method, but the solution was sprayed into a single axe-cut girdle extending around the trunk. The girdle consisted of a continuous row of downward sloped axe cuts which created a frill to catch the solution.

The fifth and last method consisted of placing sodium arsenite-treated tabs of blotting paper under the bark with a special chisel-like handtool. This method and the materials and equipment needed for it have been described by Swain.[1]

RESULTS

Fig. 1 shows the relative amount of time required per tree by the five methods. It appears that the methods rank in the same order as given above, with the fifth or last method taking the most time. The power girdler takes the least time on all sizes of trees, while the next three methods are quite similar in required time. The tab method is also similar in required time for trees up to about 6 inches d.b.h., but it takes considerably more time on the larger trees.

DISCUSSION

The relative time consumed per tree by each method, however, does not completely determine the best method to use under all conditions. We will discuss some other features of these methods in order to indicate the possibilities of each.

The power girdler requires a much larger investment in equipment than do the other methods; thus, it is probably best suited for larger jobs where the equipment costs can be justified. It cannot be used on multiple stems effectively because there may not be enough room for the cutting head to pass between adjacent stems. Where stump sprout clumps are common, this limitation can make a considerable difference in its suitability for use. Trees that are girdled

[1]Swain, L. C. (1954). Economical tree killing. N. H. Agr. Expt. Sta. Bul. 408. 15 pp.

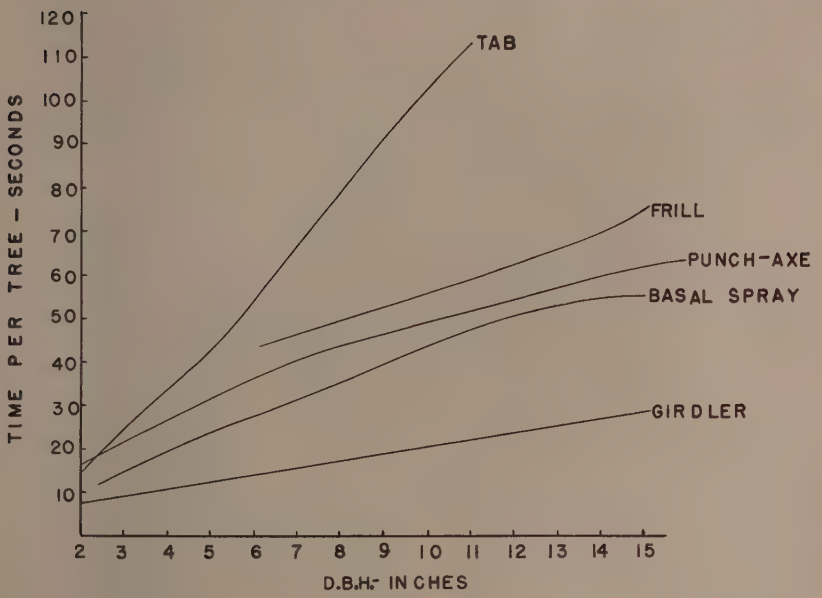

Fig.1. Time required to treat trees of different sizes by various methods.

can be expected to die much more slowly than those killed by the use of a silvicide; in some cases, 2 years or more may be required.

The basal spray method requires a relatively large amount of spray material which often creates a transportation problem. Considerable time is usually consumed in filling sprayers and in carrying the solution to the point where it is to be used. On larger trees, the method requires large amounts of spray solution, and results have not always been satisfactory.

The basal spray method seems best suited to stands of small sized trees, especially those containing many clumps of stump sprouts which are difficult to treat by other methods. It is adapted to use on small areas where the transportation of the necessary materials does not present too much of a problem.

The use of sodium arsenite solution with the punch-axe gives good results, but it is potentially poisonous to the operator, domestic livestock, and wildlife. This danger makes it unsuitable in some cases. However, it does give quick results, and it can be used on all species and sizes. The necessary equipment is relatively inexpensive, but the sodium arsenite solution is sometimes difficult to obtain.

The frill girdle with a 2,4-D and 2,4,5-T combination spray gives good results and is well adapted for use on larger trees. Smaller amounts of spray are used than in the basal spray method, thus reducing the transportation problem. It is somewhat difficult to use on multiple stems because it is not easy to make the required frill if the space between stems is narrow.

The frill girdle method is not usually used on trees under about 5 inches; however, it has many advantages in stands where the trees to be treated run over this size. It is adapted to all species, and it requires only an axe in addition to the knapsack sprayer and solution.

The tab method, while taking the most time, has some advantages. It is well suited for use on small trees, and it requires a minimum of tools and materials. It is safer to use than other sodium arsenite methods because the poison tab is completely concealed beneath the bark of the tree. It has the disadvantage of being usable only during the easy bark peeling season. The tab method is influenced by the species being treated in that trees with thin bark (such as small sized aspen and red maple) are easily treated, while trees with thick bark are difficult to treat.

SUMMARY

The experimental work indicated that the use of the power girdler was the most rapid method of killing trees. Methods using basal spray solution, punch-axe with sodium arsenite solution, and frill girdle with solution were somewhat slower, but the differences between them were small. The arsenite tab method was slower, especially in the larger diameters. Other advantages and disadvantages of each method will often determine the best one to use on any specific job.

PROGRESS REPORT ON THE CONTROLLED-ATMOSPHERE STORAGE OF JONATHAN APPLES

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JONATHAN IS THE MOST IMPORTANT variety of apples grown in Michigan. Although widely accepted as an all-purpose apple, it has a relatively short marketing season since its storage life is limited to 3 or 4 months.

Storage at 32° F., which often extends the season for Jonathan apples to early February, is hazardous since the fruit is susceptible to soft scald (Fig. 2). This physiological disorder develops less readily at 36° F. than at 32°; however, another disorder, Jonathan spot (Fig. 1), may cause serious damage at the higher temperature. Jonathan spot becomes more widespread as the storage season progresses, so that the apples must be periodically inspected and moved into market channels before excessive damage occurs.

Controlled-atmosphere storage should be useful in prolonging the storage life of Jonathan apples; however, its suitability to this variety has not been clearly established.

Smock (1949) found that Jonathan apples grown in New York were damaged by carbon dioxide in controlled-atmosphere storage; whereas Plagge (1942) found that this variety in Iowa could be stored in a high level of carbon dioxide without injury. Plagge and Fisher (1942) reported that Jonathan spot was controlled and ripening was delayed by this type of storage.

In other countries, workers—for example, Van Heile (1951) in the Netherlands, Vickery, et al. (1951) and Hall (1955) in Australia, Rasmussen (1951) in Denmark, and Phillips and Poapst (1952) and Fisher (1954) in Canada—report varying degrees of success in controlling Jonathan spot and prolonging the storage and market life of Jonathan apples by controlled-atmosphere storage.

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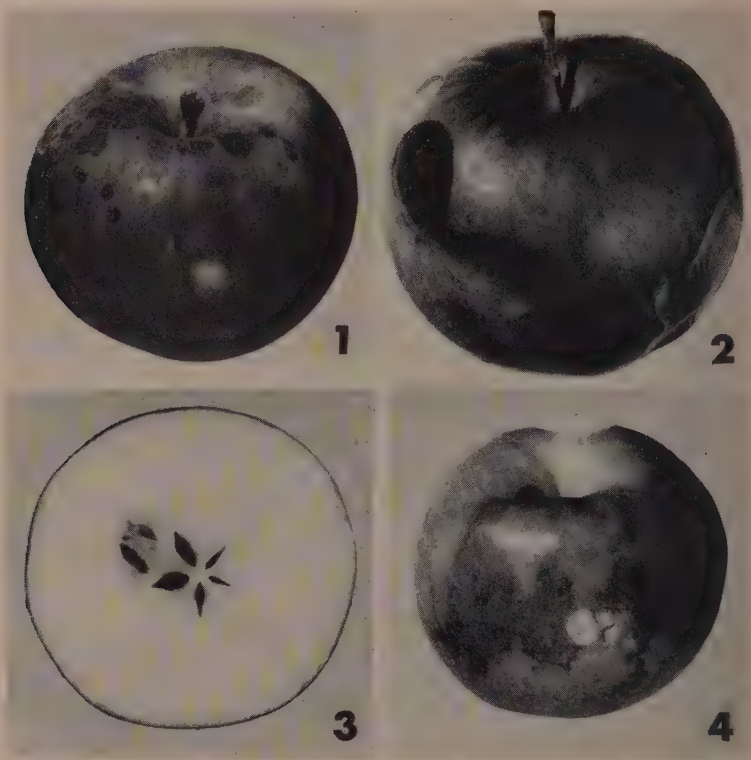

Fig. 1. Jonathan spot on Jonathan apple. The spots are brown and usually confined to the skin. Fig. 2. Soft scald (or ribbon scald) on Jonathan apple. The affected brownish and slightly sunken areas may extend through the skin and into the flesh. Fig. 3. Section of Jonathan apple showing internal or flesh injury caused by carbon dioxide. The cavities or voids in the flesh near the core are surrounded by dry, pithy and brown tissue. Fig. 4. External or surface injury caused by carbon dioxide and characterized by change of skin color from red to reddish-blue or brown.

The findings of Brooks and Harley (1934) indicate that short exposures of Jonathan apples to atmospheres containing relatively high concentrations of carbon dioxide (20 to 25 percent) before storage at 32° F. will reduce or prevent the development of soft scald.

In 1954, experiments were begun to study the response of Michigan-grown Jonathan apples to various concentrations of carbon dioxide and oxygen at several temperatures. Controlled atmospheres were evaluated as a means of maintaining quality for a longer period of time than is possible with regular cold storage.

METHODS AND MATERIALS

Apples harvested October 6, 1954, from the university orchards, and September 29, 1955, from a commercial orchard near Almont, Michigan, were sorted and randomly separated into bushel lots. The fruit was of mixed sizes in 1954, but it was separated into diameter sizes of 2¼ to 2½ inches and 2½ inches and larger in 1955. Two bushels of fruit were stored in closed metal drums in which the atmospheres were adjusted to the desired levels of carbon dioxide and oxygen by ventilation with nitrogen gas and air.

The apples were stored at temperatures of 32°, 36° and 40° F. during the 1954-55 storage season and at 32° and 36° F. during 1955-56. For the 1955-56 storage season, 38 bushels were also stored in each of three pilot-sized chambers in which the atmospheres were maintained by absorbing the excess carbon dioxide with sodium hydroxide, and by ventilating with air to add oxygen. The atmospheres and temperatures used were 7 percent carbon dioxide—14 percent oxygen at 32° to 34° F., and 5 percent carbon dioxide—3 percent oxygen at 32° to 34° and 36° F. In addition, control lots were stored in open crates and within folded polyethylene crate liners in regular storage at 32° F.

Fruit examinations at the end of the storage periods included measurements of flesh firmness by a Taylor-Magness pressure tester, and counts of fruit with external injuries, internal injuries, internal breakdown, soft scald and Jonathan spot.

RESULTS

Eating Quality

1954-55: Apples stored in controlled atmospheres at 32° and 36° F. retained excellent condition and quality to the end of the storage period on May 2 (about 7 months). This was particularly true for apples stored at 32° F. in either 2.5 percent or 5 percent carbon dioxide with 3 percent oxygen, at 36° F. in 7 percent carbon dioxide with 14 percent oxygen, and in 5 percent carbon dioxide with 3 percent oxygen. These apples were practically free of mealiness and retained good flesh texture and flavor for 10 days at room temperature after removal from storage.

Fruit stored at 32° and 36° F. in normal air showed excessive loss of quality at 5½ months. Apples stored at 40° F. for this same period of time depreciated considerably in quality, regardless of the

atmosphere employed. Many fruits showed mealiness and internal breakdown and had developed an old flavor, either upon removal from storage or after 10 days at room temperature.

1955-56: Results of experiments using sealed 2-bushel chambers are listed in Table 1.

TABLE 1—Properties of Jonathan apples stored 7 months in regular storage and controlled atmospheres: 1955-56 (averages for 2 bushels of apples)

Atmosphere	Normal air	5% CO_2 3% O_2	2.5% CO_2 3% O_2	7% CO_2 14% O_2	11% CO_2 10% O_2	5% CO_2 16% O_2
Temperature	32° F.					
Properties						
Flesh firmness (pressure, lb.)	12.8	14.8	14.4	14.1	14.4	14.3
Loss in pressure (lb.)	7.1	5.1	5.5	5.8	5.5	5.6
Jonathan spot (%)	60.9	0.3	2.2	0.0	0.0	0.4
Soft scald (%)	0.0	0.0	0.0	0.0	0.0	0.0
Internal breakdown (%)	6.2	0.0	0.0	2.5	1.9	2.8
Carbon dioxide injury						
Surface (%)	0.0	0.0	0.0	3.3	0.0	7.2
Flesh (%)	0.0	0.7	0.0	0.0	1.0	0.0
Core browning (%)	0.0	8.6	5.0	22.1	48.6	17.9
Temperature	36° F.					
Properties						
Flesh firmness (pressure, lb.)	13.0	14.8	13.5	12.9	14.8	13.2
Loss in pressure (lb.)	6.9	5.1	6.4	7.0	5.1	6.7
Jonathan spot (%)	46.9	0.0	0.0	0.0	0.0	0.0
Soft scald (%)	0.0	0.0	0.0	0.0	0.0	0.0
Internal breakdown (%)	6.4	0.0	0.0	6.0	3.2	6.8
Carbon dioxide injury						
Surface (%)	0.0	0.0	0.0	12.2	10.5	10.9
Flesh (%)	0.0	1.5	0.7	5.0	1.5	0.0
Core browning (%)	0.0	3.6	4.3	3.1	21.4	0.7

The best retention of quality for 7 months of storage was attained with 2.5 or 5 percent carbon dioxide in combination with 3 percent oxygen. The fruit under these conditions was firm and free of internal breakdown. The smaller apples (2¼ to 2½ inches in diameter) showed a slight amount of internal breakdown after holding for 2 weeks at room temperature; this breakdown was the least widespread in the apples that were stored in 5 percent carbon dioxide with 3 per-

cent oxygen at 32° F. After these treatments, the market life of fruit 2½ inches or larger in diameter was limited to less than 2 weeks because of the development of excessive breakdown and mealiness.

Following the other treatments, the smaller-sized fruit varied from slightly to seriously mealy after 2 weeks; the large fruit was unmarketable in about 1 week.

Differences in flesh firmness (as determined by pressure tests) were marked at 32° F., with the controlled-atmosphere fruit 1.3 to 2.0 pounds more firm than those from regular air at the end of the storage period on April 27.

Best quality retention for fruit stored in pilot-sized chambers was attained in an atmosphere of 5 percent carbon dioxide and 3 percent oxygen at 32° to 34° F. This is shown in Table 2 by the lowest amount of internal breakdown and the smallest decrease in flesh firmness at the end of the storage period. Storage at 32° F. in regular air was slightly better in retention of flesh firmness than either of the controlled atmospheres at 38° F. The firmest apples (5 percent CO_2 with 3 percent O_2 at 32° to 34° F.) were marketable for 1 to 2 weeks; whereas the others were unmarketable after 1 week due to the development of mealiness and off-flavor.

Although slightly lacking in typical Jonathan flavor upon removal from storage, all fruit in controlled atmospheres was crisp, juicy, and rated as highly acceptable for eating and cooking purposes.

TABLE 2—Properties of Jonathan apples stored 7 months in regular storage and in 38-bushel capacity controlled-atmosphere chambers: 1955-56

Atmosphere	Normal air	5% CO_2 3% O_2	5% CO_2 3% O_2	7% CO_2 14% O_2
Temperature	32° F.	32°—34° F.	38° F.	38° F.
Properties				
Flesh firmness (pressure, lb.)	14.2	15.1	13.7	13.5
Loss in pressure (lb.)	5.7	4.8	6.2	6.4
Jonathan spot (%)	61.3	0.2	0.2	0.0
Soft scald (%)	0.0	0.0	0.0	0.0
Internal breakdown (%)	13.4	1.8	3.5	5.2
Carbon dioxide injury				
Surface (%)	0.0	0.1	0.0	3.3
Flesh (%)	0.0	1.0	10.5	0.5
Core browning (%)	6.0	21.5	6.0	9.0

Jonathan Spot

1954-55: During the 1954-55 storage season, controlled atmospheres proved highly helpful in preventing the development of Jonathan spot. As shown in Table 3, the percentage of fruit developing spot when stored to March 20 in regular air was excessive; little or none was found in atmospheres containing 2.5 percent or greater amounts of carbon dioxide.

1955-56: Fruit stored in normal air at 32° and 36° F. showed 60.9 and 46.9 percent, respectively, of the fruit to be affected by Jonathan spot at the time of removal from the storage chambers on April 27 (see Table 1). A slight amount of Jonathan spot was evident on the fruit in controlled atmospheres at 32° F. However, it was

TABLE 3—Percentage of Jonathan apples developing Jonathan spot, soft scald and carbon dioxide injury: 1954-55 (averages for 2 bushels of apples)

Treatment		Temperature and date of examination				
Storage atmosphere		40° F.	36° F.		32° F.	
Carbon dioxide	Oxygen	March 20	March 20	May 2	March 20	May 2
			Jonathan Spot			
0.5	3.0	7	6	26	1	28
2.5	3.0	0	1	1	0	3
5.0	3.0	5	1	1	0	0
7.0	14.0	0	0	0	0	0
Normal air		30	35	†	18	†
			Soft Scald			
0.5	3.0	0	0	0	0	0
2.5	3.0	0	0	0	0‡	0‡
5.0	3.0	0	0	0	0	0
7.0	14.0	0	0	0	0	0
Normal air		0	0	†	52	†
			Carbon Dioxide Injury			
0.5	3.0	0	0	0	0	0
2.5	3.0	33*	0	0	0	0
5.0	3.0	17*	5*	8*	0	0
7.0	14.0	12*	0	0	0	8§
Normal air		0	0	†	0	†

*Flesh injury mostly at core area.
†Fruit discarded following March 20 examination.
‡Some fruit used for respiration studies developed soft scald (see page 697).
§Mostly discoloration of skin.

of minor extent and may have been present at the time of placement in storage. Similar results were obtained for fruit stored in pilot-sized chambers of 38 bushels capacity (see Table 2).

Soft Scald

1954-55: Controlled-atmosphere storage proved very effective in reducing the occurrence of soft scald. The fruit was first examined December 15; at that time, only apples in storage at 32° F. in normal air showed soft scald, with 34 percent of the fruit affected. By March 20, 52 percent of the apples were affected. As shown in Table 3, all apples stored at 32° F. in controlled atmospheres and which had not been disturbed in storage between December 15 and March 20 remained free of injury.

Curiously, several lots of fruit which had been removed from controlled atmospheres for several days in February for respiration determinations and then returned to the storage chambers developed soft scald. Injury was minor in one lot, but it amounted to 18 percent of the fruit in another lot which had been temporarily removed from the 2.5 percent carbon dioxide—3 percent oxygen atmosphere.

A marked reduction in the incidence of soft scald development at 32° F. was also observed in a companion test of apples stored in sealed plastic film liners in individual storage containers of 1 bushel capacity.

Fruit stored at 36° and 40° F. remained free of soft scald for the entire storage period (Table 3).

1955-56: Soft scald was not a problem during the 1955-56 storage season; therefore, the observed effects of controlled atmospheres in preventing this disorder the previous season were not confirmed.

Carbon Dioxide Tolerance

1954-55: Carbon dioxide injury occurred on Jonathan under the controlled-atmosphere conditions of this test. The injury was characterized by the development of dry, pithy areas in the flesh and near the core of the fruit, together with large cavities or voids in the affected tissues (Fig. 3). Carbon dioxide injury also appeared as flesh-browning which began at the skin and spread to various depths in the flesh.

There was no evidence of carbon dioxide injury when the fruit in the controlled-atmosphere chambers was first inspected on De-

cember 15. This was also true on March 20 for fruit stored at 32° and 36° F., except for that stored in 5 percent carbon dioxide with 3 percent oxygen at the latter temperature (Table 3). Flesh injuries of the void or cavity type amounted to 5 percent at this time. Considerable carbon dioxide injury of the flesh resulted from storage at 40° F. to March 20 in atmospheres containing 2.5, 5, and 7 percent carbon dioxide.

Storage to May 2 resulted in carbon dioxide injury in two cases (Table 3). At 32° F. in 7 percent carbon dioxide with 14 percent oxygen, 8 percent of the apples were injured; of this amount, 3 percent showed a necrotic condition of the epidermal tissues with practically no flesh discoloration. The other 5 percent showed surface injury characterized by an external darkening of the anthocyanins in the epidermis to a reddish-blue color (see Fig. 4).

The fruit at 36° F. at 5 percent carbon dioxide—3 percent oxygen had shown injury at the earlier inspection; a slightly greater amount of the same type of injury was evident at the final inspection. Holding the apples for 10 days at 70 to 75° F. after removal from storage did not affect the incidence or severity of damage.

1955-56: As in the previous storage season, symptoms of carbon dioxide injury were less evident with storage at 32° F. than at higher temperatures. Complete freedom from injury in controlled atmospheres occurred in 2.5 percent carbon dioxide with 3 percent oxygen at 32° F. (see Table 1). Apples in two other atmospheres at this temperature, 11 percent carbon dioxide—10 percent oxygen, and 5 percent carbon dioxide—3 percent oxygen, were practically free of surface injury, but they showed a small quantity of flesh injury.

There was no surface injury at the higher storage temperatures with either 2.5 or 5 percent carbon dioxide with 3 percent oxygen, but internal injury affected 0.7 to 1.5 percent of these apples. All of the damage was of minor extent; although the fruit was unmarketable, it was of edible quality in regard to flesh texture and flavor.

The external symptoms of damage caused by carbon dioxide were the development of bluish and brownish discolorations on the epidermis. Internal injury appeared as voids or cavities surrounded by dry, browned tissue in the flesh, rather than in the core area as observed the previous season.

A slight browning of the tissues at the core was noted for all controlled-atmosphere treatments and for regular air storage at 38° F.

This disorder was considered of minor importance in respect to marketability of the fruit and did not develop further upon holding the fruit at room temperatures for 2 weeks.

DISCUSSION AND SUMMARY

An outstanding advantage of controlled-atmosphere storage for Jonathan apples was the control of two serious storage disorders, Jonathan spot and soft scald. Jonathan spot was widespread in regular storage during both seasons, becoming prevalent after about 4 months at 36° F., and 7 months at 32° F. It was effectively controlled at all temperatures (32° to 40° F.) in atmospheres containing 2.5 percent or higher concentrations of carbon dioxide.

Soft scald was practically eliminated by the application of controlled-atmosphere storage during the 1954-55 season when it occurred as a serious storage disorder. Further tests must confirm this result, since soft scald was not a problem in 1955-56. However, the report of other workers (Brooks and Harley, 1934) shows that increased levels of carbon dioxide inhibit soft scald development.

Satisfactory eating quality of the fruit was retained for 7 months in the two seasons tested. Decreased amounts of internal breakdown and a more firm flesh texture upon removal from storage were characteristic of controlled-atmosphere fruit.

Furthermore, apples from controlled atmospheres subsequently remained free of mealiness at room temperatures longer than fruit which had been in regular storage. Retention of good quality and condition for simulated market periods of 2 weeks duration was noted.

Fruit damage attributable to above-normal concentrations of carbon dioxide was the only factor limiting the success of controlled atmospheres for Jonathan apples. Low temperatures (32° F.) minimized the amount of damage compared to higher storage temperatures (36°, 38°, and 40° F.), and carbon dioxide levels of 2.5 percent caused less injury than higher concentrations.

Best storage was attained in 5 percent carbon dioxide with 3 percent oxygen at 32° F. Under these conditions, external and internal injury by carbon dioxide amounted to a maximum of 1.1 percent (Table 2). This degree of injury, although undesirable, seemed of negligible importance when we consider the benefits of controlling Jonathan spot and soft scald and the retention of eating quality.

According to the present evidence, it is believed that Jonathan

apples can be stored advantageously from harvest to the following May in controlled atmospheres of 2.5 to 5 percent carbon dioxide and 3 percent oxygen at 32° F.

LITERATURE CITED

Brooks, C., and C. P. Harley (1934). Soft scald and soggy breakdown of apples. Jour. Agr. Res. 49: 55-69.

Fisher, D. V. (1954). Dept. Agr. Expt. Sta., Summerland, B. C., Canada. Private communication.

Hall, E. G. (1955). Commonwealth Scientific and Industrial Research Organization, Division of Food Preservation and Transport, New South Wales, Australia. Private communication.

Phillips, W. R., and P. A. Poapst (1952). Storage of apples. Canada Dept. Agr. Pub. 776. 42 pp.

Plagge, H. H. (1942). Controlled-atmosphere storage for Jonathan apples as affected by restricted ventilation. Refrig. Eng. 43: 215-220.

———————, and D. V. Fisher (1942). Pectic change in Jonathan apples is a measure of ripening under differential carbon dioxide treatments. Proc. Amer. Soc. Hort. Sci. 40: 169-171.

Rasmussen, P. Molls (1951). Gas storage of apples in Denmark. Proc. Eighth Int. Cong. Refrig.: 420-422.

Smock, R. M. (1949). Controlled-atmosphere storage of apples. Cornell Ext. Bul. 759. 39 pp.

VanHiele, T. (1951). Gas storage of fruits in the Netherlands. Proc. Eighth Int. Cong. Refrig.: 410-415.

Vickery, J. R.; F. E. Heulin, E. G. Hall and G. B. Tindale (1951). The gas storage of apples and pears in Australia. Proc. Eighth Int. Cong. Refrig.: 416-420.

RECREATIONAL USE OF THE KELLOGG FOREST

By WALTER A. LEMMIEN and AELRED D. GEIS[1]

RECREATION PLAYS an important role in the American way of life. The tensions of modern living, the 40-hour work week, and paid vacations have all tended to greatly increase the demand for outdoor recreation.

National estimates of recreational use are impressive. The number of recreational visits to national forests increased from 18 million in 1941 to 30 million in 1951. National park visitors increased from 21 million to 37 million over the same period. State park visitors numbered 150 million in 1952. Some 16 million fishing licenses and 13 million hunting licenses were sold in 1951 alone.

It is estimated that more than a third of the hunters and fishermen go to forested areas for their sport. The annual cost to the hunters and fishermen in the forest for travel, food and lodging is currently placed at about 750 million dollars. At least half a million people earn all or part of their living supplying goods and services to forest recreationists.[2]

Small forest tracts have been largely overlooked in the literature pertaining to the recreational importance of forest lands. Large areas, such as national, regional, or state forests, are usually featured. This paper, however, focussed on the recreational use of a small tract of 515 acres located in southwestern Michigan.

HISTORY AND DEVELOPMENT

The Kellogg Forest consists of 515 acres located 2 miles north of Augusta in Kalamazoo County, Michigan. The topography is variable, ranging from wet marsh in the creek valley to well-drained uplands

[1]Kellogg Forest, department of forestry; and department of fisheries and wildlife, respectively.
[2]Cratts, E. C., and Martha A. Dietz (1949). Forest Resources and the Nation's Economy. Yearbook of Agriculture, 1949, *Trees*. pp. 721-730. U. S. Dept. Agr., Washington. 944 pp.

ARTICLE 39-74

and severely eroded hillsides. Of the total area, only about 75 acres could be considered suitable for cultivation because of poor soil and steep topography. All but about 70 acres were cleared for agricultural use by former owners of the area.

The Kellogg Forest is owned and operated by Michigan State University. Nearly all the property was given to the University by the late Mr. W. K. Kellogg, with the first gift being made in 1932. The initial objectives of the area were forest research and demonstration of reforestation practices. The denuded and eroded areas were planted to trees and shrubs, and the existing woodlots were put under management. The 1.8 miles of Augusta Creek on the forest were improved for trout production. Hunting and fishing by permit, without restriction of the total number of participants, has been in effect since 1941.

In 1942, a road 3 miles long was completed, permitting visitors to drive through the plantations and woodlots. Signs giving plant names and other information were erected. In connection with forest management activities, many trails have been built which serve as footpaths for visitors.

In 1946, a picnic site with two tables was established beside the stream. By 1955, this site had been expanded into a picnic area of 14 tables. The picnic area is intended primarily for family groups, although some organizations and school groups use the facilities.

The development pertaining to recreational use are only one phase of the multiple-use management of the Kellogg Forest. Intensive research is being conducted in forestry, fisheries and wildlife, and allied fields. At the same time, the area is producing forest products such as posts, Christmas trees, pulpwood and sawlogs.

Some of the plantations are growing at least a cord of pulpwood per acre per year at the present time and will yield high quality sawlogs when harvested. Both the plantations and woodlots provide habitat for wildlife.

RECREATIONAL USE

The Kellogg Forest is within a half hour's drive of the cities of Battle Creek and Kalamazoo, as well as numerous villages. The number of potential hunters, fishermen, picnickers and forest visitors within this area is very large; in the past several years, recreational use of the forest increased sharply.

The number of people hunting and fishing, visits made, total

TABLE 1—Hunting and fishing use of the Kellogg Forest: 1950-1955

Type of use	1950	1951	1952	1953	1954	1955	6-year total
Fishing:							
No. of fishermen	709	522	607	736	917	1,050	4,541
No. of visits by fishermen	1,363	1,112	1,251	1,573	1,415	2,031	8,745
Total hours fished	3,545	2,945	3,252	4,096	3,682	5,350	22,870
No. of trout caught	903	626	1,472	1,134	1,488	1,427	7,050
Hunting:							
No. of hunters	443	482	554	578	572	587	3,016
No. of visits by hunters	886	972	1,016	1,138	1,021	954	5,987
Total hours hunted	1,772	2,114	2,096	2,342	2,349	2,042	12,715
Game bagged:							
Rabbits	319	267	192	245	205	176	1,400
Pheasants	9	9	7	13	9	22	69
Fox squirrels	21	17	10	6	15	27	96
Woodcock	6	10	2	0	2	1	21
Muskrats*	22	27	20	8	16	4	97
Others†	6	8	13	10	16	11	64

*Caught by trapping.
†Includes ducks, geese, grouse, foxes, weasels and mink.

time spent, and numbers of fish caught or game bagged have been recorded each year (Table 1). These data are a portion of the hunting and fishing information obtained by a compulsory permit system.

In 1955, the number of picnickers and other visitors was recorded. The number of cars and number of people per car were counted on

TABLE 2—Visitor and picnic use of the Kellogg Forest: 1955

Type of use	Number of cars	Number of people	Hours spent
Picnickers:			
General public	1,472	6,044	15,110
Organized groups	.....	1,686	1,405
Total	1,472	7,730	16,515
Visitors:			
General public	1,639	6,058	4,543
Organized groups	.....	524	786
Total	1,639	6,582	5,329
All users	3,111	14,312	21,844

given days selected at random. The number of visitors in organized groups was also recorded. This information is presented in Table 2.

The visitor category includes all individuals who drove or hiked in the forest but did not picnic, hunt or fish. Picnickers include all persons who used the picnic area, although they may have also hiked or toured the forest. Each person was recorded only once each day, even though he may have engaged in several activities.

Picnickers averaged 4.1 persons per car, while the average number of visitors per car was 3.7 persons. About 50 percent of the picnic and visit use occurred on Sundays; 15 percent on Saturdays; and the other 35 percent was spread over the 5 weekdays.

RECREATIONAL VALUES

Recreational values are very difficult to evaluate. A money value cannot be placed on the satisfaction a hunter feels as he hears his hound running a rabbit, or the thrill a fisherman gets as a trout rises to his fly, or in the pleasure of picnicking beside a shaded stream. However, by considering the time people spend, the distance they travel, and pounds of game harvested, it is possible to obtain some indication of the recreational value of the area.

A total of 29,236 hours was spent in hunting, fishing, picnicking or visiting in the Kellogg Forest in 1955.

By considering the home addresses of people receiving hunting and fishing permits and average party size, it is possible to estimate the distance traveled to hunt and fish at the Kellogg Forest. In 1955, the average hunting party consisted of 1.8 people who drove 18.6 miles round trip per visit. The average fishing party consisted of 2.1 people who traveled 26.2 miles round trip per visit. It can be assumed that visitors and picnickers traveled a similar distance per visit. For 1955, it is estimated that hunters drove 9,280 miles; fishermen, 25,400 miles; and visitors and picnickers, 69,685 miles—making a total distance of 104,375 miles in pursuit of recreation at the Kellogg Forest.

During the 6-year period 1950-1955, 2,115 pounds of pan-ready trout and 2,373 pounds of dressed game were taken from Kellogg Forest. The weight of the fish was calculated largely from the size of fish when released, and the assumption was made that no significant

growth occurred before they were caught. The dressed game weights were those used by Shick.[3]

The meat return from hunting and fishing is extremely low when the effort applied is considered. The average fishing visit yielded .25 pound of pan-ready trout, and the average hunting visit resulted in .40 pound of dressed game. It appears that the public is willing to spend time and effort in hunting and fishing with very little meat in return.

COST OF PROVIDING RECREATION

Some management expenses can and should be charged to recreation. Construction of roads and trails is essential to management of the area, but improvement and regular maintenance would not be necessary were it not for public use. Road repair and maintenance costs for the past several years has been about $375 per year. Since all visitors and picnickers and some of the hunters and fishermen use these roads, the maintenance cost is less than 4 cents per person.

Maintenance of the picnic area has cost about $275 per year. The cost of present equipment such as fireplaces, tables and toilets can be depreciated at $45 per year. Thus, for 1955, about $325 can be charged to picnic area operation, or 4 cents per picnicker.

Each year, trout have been planted in the stream. It has been estimated that the cost of rearing trout for planting has been about $500 per year for the last 4 years. For 1955, the cost of the trout planted was 48 cents per fisherman. This cost is borne by the fishermen of Michigan, largely through the purchase of fishing licenses and trout stamps.

There is little in the routine operation of the Forest that can be charged to small game management. Some wildlife practices such as planting food patches and supplying nesting boxes have been applied, but the value of these to small game production is unknown. The woodlots would have been managed in about the same manner as they have been and the denuded hills reforested in the same way even if the wildlife production had been considered more fully.

A wide variety of species has been planted in small blocks and strips. This arrangement has produced a large amount of edge that is considered desirable for small game. A few openings and some

[3]Shick, Charles (1955). Value of Michigan's 1954 game and fur crop. Cooperative Extension Service, Michigan State University, East Lansing. (Unpublished mimeo)

areas now occupied by wildlife shrubs could have been planted to wood producing species if wood production was the only objective of the area.

Increased recreational use of the Forest has created the need for more supervision of these activities. In certain periods of high fire danger, there is some added risk by having a number of visitors or hunters traveling about the dry woods. In general, there has been very little land use conflict between wood production and recreation. Only a small amount of land has been needed solely for recreation, and many of the practices in wood production such as pruning, thinning and protection have enhanced the recreational possibilities of the Forest.

SUMMARY

The Kellogg Forest is a 515-acre tract of land in southwestern Michigan. Formerly 85 percent of the area had been cleared for agricultural purposes. It has been reforested and is now managed as a multiple use area.

A rather large recreational use of this tract has developed. Over the past 6 years, an average of 1,260 people have spent 5,930 hours hunting and fishing on the area annually. The game return per visit has been very low, averaging .24 pound for fishermen, and .40 pound for hunters. In 1955, 16,316 people spent 29,236 hours and drove 104,375 miles in pursuit of recreation at the Kellogg Forest.

The cost of supplying recreation has been very low, only a few cents per person. Forest management for both wood production and recreation has worked well with little conflict. In most cases, the activities connected with wood production either benefited or at least did not reduce recreational values.

JOURNAL ARTICLE ABSTRACTS

The Influence of Environmental Conditions on the Growth and Dissociation of *Brucella abortus*

SANDERS, E., AND I. F. HUDDLESON

Am. Jour. Vet. Res. 17: 324-330. 1956. (Journal Article 1809 from the Michigan Agricultural Experiment Station)

The dissociation of S and S1 types of *Br. abortus* in liquid mediums can be prevented or significantly lowered by an adequate supply of air or oxygen to the culture. This can be accomplished by agitation, by aeration with oxygen, or by growing the cells in a shallow layer of medium.

The presence of glucose, fructose, sucrose, or DL-alanine in liquid medium in test tubes increased the dissociation of S types of *Br. abortus;* but, in the presence of these agents in a shallow layer of medium in Erlenmeyer flasks, there was little dissociation observed.

The growth conditions which favored stable S and S1 colonial types were also suitable for rapid multiplication of those cells and also for non-S colonial types in the absence of S types. In cultures inoculated with mixed cell populations, however, the growth of non-S types of cells was suppressed in a shallow layer of medium.

The results of this study show that the atmosphere and conditions under which cells of *Br. abortus* are grown in liquid mediums are factors as important as metabolites in the causation and prevention of dissociation. Furthermore, it is not possible to evaluate the influence of metabolites on dissociation without considering the atmospheric conditions under which the cells are multiplying.

Tumor Inhibitors in *Boletus Edulis* and Other Holobasidiomycetes

LUCAS, E. H.; R. L. RINGLER, R. U. BYERRUM, J. A. STEVENS, D. A. CLARKE AND C. C. STOCK

Antibiotics and Chemotherapy 7: 1-4. 1957. (Journal Article 1816 from the Michigan Agricultural Experiment Station)

Water extracts of the mushroom *Boletus edulis* showed retardation of growth of implanted Crocker mouse sarcoma 180 in experiments conducted since 1950.

Attempts to date to isolate the active principle have resulted in the separation of a peptide containing at least nine amino acids, which have been identified. Three other substances which gave a blue color with ninhydrin were also obtained, but they have not yet been identified.

In vitro culture of *Boletus edulis* from spores and sporophore tissue has been successful, but very slow growth and lack of elaboration of the active principle under these conditions prompted the inclusion of other holobasidiomycetes in culture experiments. Two species, *Collybia longipes* and *Clitopilus abortivus,* yielded tumor-retarding principles in shake cultures.

Some Aspects of Thyroid Physiology in Rainbow Trout

FROMM, PAUL O., AND E. P. REINEKE

Jour. Cellular and Comparative Physiology 48: 393-404. 1956. (Journal Article 1828 from the Michigan Agricultural Experiment Station)

The function of the thyroid of fish still is a matter of conjecture. The "gland" consists of scattered follicles located in the lower jaw region in Rainbow trout, and surgical removal is impossible. The follicles avidly accumulate iodine, and radiothyroidectomy was accomplished by injection of 250 microcuries of I^{131}.

Measurements of the oxygen consumption of normal and thyroidectomized fish revealed no significant difference between the two groups; this indicates that the trout thyroid is not involved in regulation of the general metabolism. The time required for the follicles to release one-half of the accumulated radioiodine (output half-time) is 15.5 ± 4.0 days for normal, intact Rainbow trout.

Influence of Particle Size, Water Solubility, and Placement of Fertilizers on the Nutrient Value of Phosphorus in Mixed Fertilizers

LAWTON, K.; C. APOSTOLAKIS, R. L. COOK AND W. L. HILL

Soil Sci. 82: 465-476. 1956. (Journal Article 1867 from the Michigan Agricultural Experiment Station)

Greenhouse and field experiments were conducted to study the effects of: (1) fertilizer particle size, (2) phosphate water solubility, (3) method of fertilizer placement, and (4) type of soil on the yield and absorption of fertilizer P by corn and field beans.

In mixed or broadcast placement of granular fertilizer, the absorption of fertilizer P by plants was closely related to the percent of the phosphate fraction soluble in water. When pulverant materials were well mixed with soil, large differences in the water-soluble phosphorus content of fertilizers had little effect on the absorption of labelled P by crops.

Banding, like granulation, reduced the initial surface contact between soil and fertilizer. With materials high in water-soluble P, this method of placement resulted in the most efficient use by plants of applied phosphate. Compared with mixed placement, the use of water-insoluble phosphates in bands resulted in low absorption of fertilizer P and reduced dry matter yields.

Establishment of Alfalfa in Wide-Row Corn

TESAR, MILO B.

Agron. Jour. 49: 63-68. 1956. (Journal Article 1906 from the Michigan Agricultural Experiment Station)

Drilling and packing alfalfa seed in a band over fertilizers containing P and K between corn rows 60 or 80 inches wide on a silt loam soil resulted in alfalfa stands and yields not significantly different from those produced by seedings in oats. Stands were not established reliably on a sandy loam soil.

Packing after drilling resulted in stands 28 to 109 percent better than stands established without packing in 3-year tests. Seedings in oats were affected less by adverse moisture conditions in July and August, indicating that seedings will be more difficult to establish in corn than in oats in drier summers or drier portions of the corn belt.

Since very few seedlings became established in the area about 1½ feet wide over the corn, seedings in corn were not as uniform as those made in oats.

Alteration of Biotite to Vermiculite by Plant Growth

MORTLAND, M. M.; K. LAWTON AND G. UEHARA

Soil Sci. 82: 477-481. 1956. (Journal Article 1920 from the Michigan Agricultural Experiment Station)

Biotite was supplied as the sole source of potassium to growing wheat plants. After four crops of wheat, X-ray diffraction patterns indicated an alteration of biotite to vermiculite.

The amount of biotite weathering was inversely proportional to the amount of biotite supplied to the wheat. As potassium stress was increased, the greater was the alteration of biotite to vermiculite. Cation exchange capacity and ethylene glycol retention increased, while the total charge decreased as the biotite weathered. No hydrous mica intermediates were observed in the transition of biotite to vermiculite.

It does not seem that biotite can persist in the clay fraction of soil horizons subjected to extensive biological influence.

Effects of Gamma Radiation on the Pectic Constituents of Fruits and Vegetables

MCARDLE, F. J., AND J. V. NEHEMIAS

Food Tech. 10: 599-601. 1956. (Journal Article 1926 from the Michigan Agricultural Experiment Station.)

A relationship is indicated between radiation-induced softening of apple and carrot tissues and the transformation of pectic substances which occurs in these plant materials when they are irradiated.

Gamma ray doses of 0.5×10^6, 1.0×10^6, 1.5×10^6, and 2.0×10^6 rep. were administered to apples and carrots from a CO^{60} source. Protopectin, pectin, and pectic acid fractions of the irradiated products were then compared with similar extracts from nonirradiated controls.

Degradation of protopectin to soluble pectins and reduction in total pectic substances accompanied the radiation process. Relative viscosity of the three pectic fractions decreased, indicating a decrease in size of pectic molecules. These pectic changes correlated directly with quantitative measurements of tissue softening.

Effects of Type of Surfaces on Pesticidal Dust Depositions

BRITTAIN, R. W., AND W. M. CARLETON

Agr. Engr. 38: 22-25. 1957. (Journal Article 1931 from the Michigan Agricultural Experiment Station)

Plant surface types affect efficiency of dust deposition. The study reported here was a part of the larger objective of gaining a thorough understanding of the dusting process.

Various surfaces were dusted with standard and micronized dusts. Results included the following:

(1) Larger particles tended to embed themselves in soft, waxy surface materials; this resulted in larger deposits. The opposite was true on hard, slick surfaces where the deposition of the finer particles was much greater.

(2) Deposits of micronized dust increased with increased air velocity, but deposition of the standard dust was actually less.

(3) Pubescent (hairy) plant surfaces experienced higher deposits than did smooth leaves. In all cases on actual plant leaves, there was a higher deposit on the upper leaf surfaces.

(4) More dust was deposited as the leaf appoached a position parallel to the air-dust stream than where it was perpendicular to it.

The Synthesis of Several Acid Analogs of 2-Mercaptobenzimidazole

REBSTOCK, T. L.; C. D. BALL, C. L. HAMNER AND H. M. SELL

Jour. Amer. Chem. Soc. 78: 5831-5832. 1956. (Journal Article 1932 from the Michigan Agricultural Experiment Station)

Twenty-three acid analogs of 2-mercaptobenzimidazole were prepared to study the effect of chemical structure on growth inhibition of plants.

The following new compounds were synthesized: α (2-benzimidazolylthio)-propionic, (5-chloro-2-benzimidazolylthio)acetic, α (5-chloro-2-benzimidazolylthio) propionic, β (5-chloro-2-benzimidazolylthio) propionic, (4, 6-dichloro-2-benzimidazolylthio) acetic, (5, 6-dichloro-2-benzimidazolylthio) acetic, α (5, 6-dichloro-2-benzimidazolylthio) propionic, (4, 5, 6-trichloro-2-benzimidazolylthio) acetic, α (4, 5, 6-trichloro-2-benzimidazolylthio)propionic, (5-bromo-2-benzimidazolylthio)acetic, α (5-bromo-2-benzimidazolylthio)propionic, (5-nitro-2-benzimidazolylthio)acetic, α (5-nitro-2-benzimidazolylthio)propionic, (5-methoxy-2-benzimidazolylthio)acetic, α (5-methoxy-2-benzimidazolylthio)propionic, (5-methyl-2-benzimidazolylthio)acetic, α (5-methyl-2-benzimidazolylthio)propionic, (4, 6-dimethyl-2-benzimidazolylthio)acetic, α (4, 6-dimethyl-2-benzimidazolylthio)propionic, (5,6-dimethyl-2-benzimidazolylthio)acetic, α (5, 6-dimethyl-2-benzimidazolylthio)propionic, (5-phenyl-2-benzimidazolylthio)acetic and α (5-phenyl-2-benzimidazolylthio)propionic acids.

Trinitrobenzene Adducts of Various Indole Compounds

REBSTOCK, T. L.; L. E. WELLER AND H. M. SELL

Jour. Organic Chem. 21: 1515-1516. 1956. (Journal Article 1933 from the Michigan Agricultural Experiment Station)

Twenty-five trinitrobenzene adducts of various indole compounds were prepared and their chemical and physical properties were determined. The ease of preparation makes these derivatives a convenient method of identifying indole compounds occurring in natural products.

Wear Tests of Plowshare Materials

MOHSENIN, NURI; H. L. WOMOCHEL, D. J. HARVEY AND W. M. CARLETON

Agr. Engr. 37: 816-820. 1956. (Journal Article 1937 from the Michigan Agricultural Experiment Station)

Available information on the wear of metals in the soil is quite meager. Work at Michigan State University covered both laboratory and field tests of high and low-carbon cast irons and of a new type of cast iron called nodular.

By using accelerated testing, the following conclusions were obtained:

1. Very high correlation between laboratory and field tests with the new procedure.
2. High carbon, chilled iron was superior to all other kinds of cast iron in wear resistance.
3. Low carbon, ordinary, unchilled cast iron was superior to all the unchilled irons except nodular.
4. The effect of alloying elements was not significant in the chilled condition. Alloying elements contributed greatly to wear resistance in the unchilled condition.
5. Hardness measurements alone are not sufficient as an index of wear resistance of cast iron in soil.
6. Nodular iron, because of its moderate resistance to wear, its ductility and impact resistance, and its greater hardness in the unchilled condition, promises to be a good plowshare material.

A Low-Level Piperazine Study on Pigs Experimentally Infected with *Ascaris Lumbricoides*

LINDQUIST, W. D.

Am. Jour. Vet. Res. 18: 119-120. (Journal Article 1938 from the Michigan Agricultural Experiment Station)

One-tenth therapeutic dose per day of polymeric piperazine-1-carbodithioic acid given in the feed 1 week before and 3 weeks after infection failed to prevent migration of *Ascaris lumbricoides* larvae.

Respiratory embarrassment and liver scarring resulted, although no worms were recovered from the small intestines of any of the pigs. Uninfected control litter mates showed no liver or lung involvement, and their weight gain was slightly greater during the experiment.

Calcium and Zinc in Parakeratosis of Swine

LUECKE, R. W.; J. A. HOEFER, W. S. BRAMMELL AND D. A. SCHMIDT

Jour. An. Science 16: 3-11. 1957. (Journal Article 1940 from the Michigan Agricultural Experiment Station)

The data contained in this paper are a result of two separate experiments involving a total of 10 lots of 10 pigs each. In the first trial, the feeding of a ration containing 0.65 percent calcium and 0.53 percent phosphorus resulted

in good growth; however, a 10 percent incidence of parakeratosis was noted. The feeding of a ration containing 1.25 percent calcium and 0.95 percent phosphorus resulted in very poor growth and a 100 percent incidence of parakeratosis.

In the second trial, the feeding of a ration containing 0.51 percent calcium and 0.61 percent phosphorus resulted in depressed growth and a 40 percent incidence of parakeratosis. In addition, rations containing 1.21 percent calcium and 1.90 percent calcium, both with 0.61 percent phosphorus, resulted in severely depressed growth and a 100 percent incidence of parakeratosis.

In all cases, symptoms of parakeratosis were alleviated by zinc therapy.

In the second trial, preliminary studies indicated that dietary zinc increased serum alkaline phosphatase activity.

Initiation of Lactation at Parturition

MEITES, JOSEPH

Les Annales d'Endocrinologie 17: 519-525. 1956. (Journal Article 1941 from the Michigan Agricultural Experiment Station)

This is a review and discussion of recent work on the initiation of lactation performed here and elsewhere.

Specific Gravity and Chemical Composition of the Untrimmed Ham as Related to Leanness of Pork Carcasses

PRICE, J. F.; A. M. PEARSON AND E. J. BENNE

Jour. An. Sci. 16: 85-92. 1957. (Journal Article 1945 from the Michigan Agricultural Experiment Station)

Specific gravity of the untrimmed ham was closely related to specific gravity of the carcass (+.86); and both specific gravity values were closely associated with chemical composition, cutout percentages and loin lean area.

Specific gravity was more closely related to chemical composition and loin lean area than any other measure, indicating that specific gravity more nearly measured muscling *per se* than any other factor studied. However, backfat and live probe more closely predicted cutout.

Multiple correlation coefficients in which carcass length was combined with either backfat thickness or live probe gave little advantage over the use of either measure taken alone.

Heating Air by Solar Energy

BUELOW, F. H., AND J. S. BOYD

Agr. Engr. 38: 28-30. 1957. (Journal Article 1947 from the Michigan Agricultural Experiment Station)

A collector for heating air with solar energy was designed. The collector is intended to provide heated air for drying hay and grain on farms and supplemental heat to buildings. The operating characteristics of the collector were determined mathematically and proven experimentally. Therefore, they can be used for other solar energy air heaters to predict operating characteristics.

It was found that a heater with a collection area of 1,000 square feet and

heating air at the rate of 4,500 cubic feet per minute could raise the temperature of the air 50 degrees F. This heater is equivalent to a 72-kilowatt heater or to an oil burner using 2 gallons of fuel oil per hour.

Before Buying a Bulk Tank

HALL, C. W., AND A. K. GILLETTE

Hoard's Dairyman 102: 294. 1957. (Journal Article 1949 from the Michigan Agricultural Experiment Station)

Milkhouse size and facilities should be carefully considered before buying a bulk tank.

To provide the required clearance around the tank (usually 18 to 24 inches) it may be necessary to select a particular make, which, because of its shape, will provide this clearance where another make may not. Another possibility is to select a tank with a remote refrigeration unit.

The milkhouse should be well ventilated, particularly if the condenser is air cooled. Proper ventilation will reduce cooling costs and repairs.

The milkhouse door opening must be large enough to move the tank through. The floor should be solid, and it must not settle or heave. The drain should be located where it can be easily serviced. A hose port should be provided for the truck hose and electric cord. Electric service of 220 volts must be provided; and no light bulbs, wiring, or pipe should be placed directly over the tank.

Electrocardiographic Changes in the Thiamine-Deficient Baby Pig

MILLER, E. R.; D. A. SCHMIDT, J. A. HOEFER, R. W. LUECKE AND W. D. COLLINGS

Proc. Soc. Expmt'l. Biol. and Med. 94: 209-211. 1957. (Journal Article 1970 from the Michigan Agricultural Experiment Station)

Electrocardiograms were made weekly from birth through 5 weeks of age on 35 baby pigs receiving various subminimal and adequate levels of thiamine in the diet. Typical ECG patterns of normal and thiamine-deficient baby pigs are presented and described.

Statistically significant increases in PR time, QT time and cycle length occurred in deficient animals. Thiamine-deficient pigs consistently exhibited sinus arrhythmia. First and second degree auriculoventricular block were shown. Evidence of cardiac hypertrophy occurred in deficient animals.

Solar Radiation Availability on Surfaces in the United States as Affected by Season, Orientation, Latitude, Altitude and Cloudiness

BECKER, C. F., AND J. S. BOYD

Jour. Solar Energy Sci. and Engr. 1: 13-21. 1957. (Journal Article 1978 from the Michigan Agricultural Experiment Station)

Radiation from the sun is the primary source of all energy used by mankind. We must learn how to use solar energy directly before stockpiles of other energies are exhausted. The Weather Bureau measures and records of solar radiation upon a horizontal surface at various locations in the United States were used.

Seasonal curves of the availability of solar radiation on surfaces with various orientations were determined from the solar radiation on horizontal surfaces.

Optimum tilt angles of solar collectors for various seasons and in north latitudes of 30, 35, 40, 45 degrees are presented, along with the ratios of solar radiation on tilted surfaces to that on a horizontal surface. The calculated ratios are multiplied by the values given for a horizontal surface to find the corresponding value for a tilted surface at various latitudes.

Corrections for altitude and cloudiness are shown.

Bone Structure Changes in Pigs Infected with Hog Cholera

DUNNE, H. W.; S. C. BENBROOK, E. M. SMITH AND R. A. RUNNELLS

Jour. Am. Vet. Med. Assoc. 130: 260-265. 1957. (Journal Article 1987 from the Michigan Agricultural Experiment Station)

1. Rib lesions observed in pigs acutely infected with hog cholera occurred at the costochondral junction and were characterized by a mildly irregular epiphyseal line with an adjacent narrow transverse band of hemorrhage.
2. Subacute infections of pigs with hog cholera showed a marked widening of the epiphyseal line by an increased number of cartilage cells with enlarged lacunae.
3. Chronic cases of hog cholera commonly showed dense osseus transverse lines near the epiphyseal disc.
4. The metabolic disturbance was characterized by an early increase in phosphorus and a decrease in calcium.
5. A comparison is drawn between the occurrence of rib lesions, fetal malformation, soft shell eggs, and encephalitic symptoms as the result of virus infection.

An Outline of Principles of Antibiotic Therapy in Veterinary Medicine

SAN CLEMENTE, C. L.

M.S.U. Vet. 17: 19-25. 1956. (Journal Article 1991 from the Michigan Agricultural Experiment Station)

To help the veterinarian utilize antibiotic therapy efficiently and wisely, various aspects of the problem have been briefly discussed as follows: 1) antimicrobial spectrum; 2) factors influencing action of antibiotics; 3) correlation between *in vitro* and *in vivo* results; 4) reactions to antibiotics; 5) bacterial resistance; 6) biologic complications; 7) indiscriminate use of antibiotics; 8) combination of antibiotics; 9) reasons for therapeutic failure; 10) selection of proper antibiotic; and 11) antibiotics as growth stimulants.

Some Correlations Between Germination and Dormancy of Weed Seeds in the Laboratory and in the Field

STEINBAUER, G. P., AND B. GRIGSBY

Proc. Thirteenth North Central Weed Control Conf.: 35-36. 1956. (Journal Article 1996 from the Michigan Agricultural Experiment Station)

Comparisons were made between the laboratory germination of weed seeds immediately after harvest and germination behavior when the seeds were planted in the field. Emergence of seedlings in field plantings was closely correlated with the duration of primary dormancy as determined in the laboratory. Those

without primary dormancy, or with primary dormancy of short duration (such as corn cockle and downy bromegrass) germinated readily in the field shortly after planting. Others (such as soapwort) with a long period of primary dormancy, broken by low temperature exposure, do not germinate until the seeds have passed one winter period in the soil.

Seeds with highly specific germination requirements, such as need for alternating temperatures and the light stimulus, germinate in the field only at the soil surface—usually in the spring when seeds on the surface remain moist long enough to germinate and become established as seedlings. Several small, seeded crucifers behave in this manner.

The Relation of Chemical Structure to Biological Activity in Certain Organic Compounds

SINGH, J. P., AND C. L. HAMNER

Indian Jour. Hort. 13: 1-32. 1956. (Journal Article 2016 from the Michigan Agricultural Experiment Station)

An attempt has been made to determine whether or not there is any correlation between structure and activity of various organic compounds which were tested.

It has been found that many naphthoic acid compounds are active as growth regulators. These compounds are similar in structure to naphthaleneacetic acid. The carboxyl group is attached through methylene on the ring nucleus. If the carboxyl group is in the 1-position, the compound is more active than when it is in the 2-position. When an hydroxyl group is added in different positions on the ring structure (for example, 1 and 3 positions), activity is reversed. Apparently the compound acts as an antiauxin, as indicated by its action in stimulating root elongation.

The structures of these materials also suggest that activity might be correlated with their ability to act as metal chelates. Many chelating materials were tested, and some were found to be quite active.

(Continued from back cover)

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(Continued on inside back cover)